Lummi Nation Wellhead Protection Program
Phase I

November 1997

LUMMI NATION WELLHEAD PROTECTION PROGRAM
PHASE I

Prepared For:
Lummi Indian Business Council

Funded By:
Bureau of Reclamation
(Cooperative Agreement No. 1425-5-FC-10-01480)

Prepared By:
Jeremy Freimund, Water Resources Manager

Reviewed By:

Leroy Deardorff	**Lummi Environmental Director**
Harriet Beale	**Lummi Water Resources Manager (past)**
Gordon Scott	**Lummi Land Development Manager**
Gene Decoteau	**Lummi Sewer District Manager**
Victor Solomon	**Lummi Sewer District Field Superintendent**
Andy Ross	**Lummi Water Resources Specialist**
Harry Johnsen	**Raas, Johnsen, & Stuen, P.S.**
Susan Williams	**Gover, Williams & Janov, P.C.**

November 1997

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EXECUTIVE SUMMARY

The overall purpose of the Lummi Nation Wellhead Protection Program is to protect wellhead areas within the Lummi Reservation ("Reservation") from contaminants which may have any adverse effect on the health of persons or on the integrity of the ground water resources of the Lummi Nation. The wellhead protection program is a proactive approach by the Lummi Nation to prevent contamination of ground water resources by pollution and to reduce the risks that the Lummi Nation's ground water resources will become impaired or otherwise unusable as the primary water supply for the Lummi Nation and residents of the Reservation.

The Lummi Nation finds that contamination of wellhead areas and ground water resources on the Reservation has a direct, serious, and substantial effect on the political integrity, economic security, and the health and welfare of the Lummi Nation, its members, and all persons present on the Reservation, and that those activities posing threats of such contamination, if left unregulated, also could cause such adverse impacts. Accordingly, the Lummi Natural Resources Department, in conjunction with the Lummi Planning Department, is developing a wellhead protection program for the Reservation based on the foregoing findings and the following considerations:

- As a finite resource, ground water is one of the most important and critical of the Lummi Nation's resources.
- Over 95 percent of the residential water supply for the Reservation is pumped from local ground water wells, and contamination of wellheads carries the risk of adversely affecting the health of persons drinking or using water from these supplies.
- The salmon hatchery program, which is culturally and economically significant to the Lummi Nation and its members, is dependent on ground water. No suitable alternative water sources exist on or near the Reservation for the salmon egg incubation program and salmon rearing operation.
- Ample supplies of ground water of good quality is essential to serve the purposes of the Reservation as the permanent homeland of the Lummi Nation and its members.
- Reservation ground water resources are particularly vulnerable to pollution due to geographic and hydrogeologic conditions, which may be exacerbated by future growth and development on the Reservation. The Reservation is located in a coastal area along the inland marine waters of the Puget Sound and Georgia Strait. Most of the existing water supply wells on the Reservation are located within a half mile of marine waters. Progressive salt water intrusion already has led to the closure of several of these public water supply wells. Increased pumping, possible future reductions in ground water recharge areas as the forested uplands of the Reservation are converted to residential uses, and rapid economic and population growth could further threaten the Lummi Nation's ground water resources if such activities are not managed effectively.
- Ground water resources are vulnerable to contamination by pollutants introduced on or near the ground surface by human activities. Agricultural, residential,

municipal, commercial, and industrial land uses increase the potential for ground water contamination.

- Ground water contamination could lead to the loss of the primary water supply source for the Reservation because water supply wells are difficult to replace, ground water contamination is very expensive to treat, and some damages to ground water caused by contamination may be impossible or unfeasible to mitigate.
- Alternative water sources to serve the needs of the Reservation are expensive and may not be available in amounts sufficient to replace existing supplies and to provide for future anticipated tribal economic and residential growth. Moreover, alternative water sources would require substantial amounts of funding for the infrastructure upgrades that would be necessary to import larger volumes of water onto the Reservation. Finally, alternative water sources may be subject to service interruptions over the long term due to natural or human generated disasters.

The Lummi Nation Wellhead Protection Program is being developed in three phases. Phase I, which is comprised of a susceptibility assessment and development of contingency and public involvement plans, is completed and is documented in this report. Phase II, which will include implementing the community involvement plan, spill response planning, and the development of protection measures, is scheduled to start in December 1997. Phase III, which will include developing and implementing the protection measures identified during Phase II, is scheduled to start in March 1998. A report documenting the status of the Lummi Nation Wellhead Protection Program will also be completed in March 1998. The March 1998 report will document the implementation of the community involvement plan, the spill response planning effort, and the development of protection measures. The report will also identify the 1998-2000 action plan for the Lummi Nation Wellhead Protection Program.

In the susceptibility assessment, the vulnerability of ground water wells to contamination was evaluated by characterizing the hydrogeologic setting, conducting an inventory of the water supply wells, delineating wellhead protection areas, and conducting an inventory of potential contamination sources in each wellhead protection area.

The hydrogeologic setting of the Reservation consists of unconsolidated sediments deposited as glacial outwash, glaciomarine drift, glacial till, and alluvial flood plain or delta deposits from the Fraser Glaciation (which ended about 10,000 years ago). The unconsolidated deposits consist of clay, silt, sand, gravel, and occasional boulders. Ground water is obtained primarily from the sand and gravel advance outwash deposits underlying the less permeable glaciomarine drift. Glacial till may underlie the drift and overlie the outwash deposits in limited areas. Glaciomarine drift and till deposits restrict the amount of recharge to the underlying aquifer. Because the composition of the deposits commonly change laterally over short distances, it is difficult to distinguish between the different stratigraphic units from existing well log data.

A total of 220 wellheads, test holes, and undeveloped springs were identified within the exterior boundaries of the Reservation as of February 1997. Of these, 79 (36 percent) are currently used for water supply, the use status of 9 (4 percent) of the wells is not known, and the remaining 132 (60 percent) are either no longer used or were never used. Numerous springs located along the flanks of the upland areas and seaward of the ordinary high water line have not been mapped.

Well logs are available for 71 percent of the 220 wellheads, test holes, and springs on the Reservation. Approximately two-thirds of the 220 inventoried wellheads, test holes, and springs were completed below the elevation of mean sea level. About 84 percent of the 88 wells that are currently used for water supply were completed below mean sea level.

The yield of ground water wells on the Reservation is generally low and variable over short distances. In general, wells on the Reservation yield from less than 1 gallon per minute (gpm) to approximately 60 gpm. The highest yield reported in well driller logs on the southern upland areas (Lummi Peninsula and Portage Island) is about 60 gpm. Three wells with reported yields greater than 200 gpm are located in the western section of the northern upland area of the Reservation. Although these three wells have relatively high yields, wells within about 1/4 of a mile reportedly yield from no water to 25-30 gpm.

After reviewing criteria and methods, the flow boundaries approach was selected as the basis for delineating the wellhead protection areas in the Lummi Nation Wellhead Protection Program. The flow boundaries approach was selected as the most appropriate method for the Lummi Nation Wellhead Protection Program for several reasons including:

1. The flow boundaries approach is the most protective criteria.
2. Both public supply wells and private domestic supply wells of Reservation residents are included in the Lummi Wellhead Protection Program.
3. Detailed hydrogeologic data are not available for most locations on the Reservation; in the northern upland area, the extent of the aquifer has not been determined.
4. The hydrogeologic conditions on the Reservation vary over short distances.
5. The approach is well suited to hydrogeologic settings dominated by near-surface flow boundaries as are found in many glacial and alluvial aquifers.
6. The Reservation aquifers are believed to be less than 10 square miles in area.
7. The time of travel from a well recharge area to the well may be less than 1 to 10 years which limits the utility of methods based on travel time.

As discussed in Section 3 of this Phase I report, two separate wellhead protection areas were delineated and mapped. Area 1 is the southern upland area and includes most of the Lummi Peninsula and Portage Island. Area 2 is the northern upland area and extends north of the Reservation boundary. The flood plain of the Lummi and Nooksack rivers, as well as areas north of the Reservation that contribute flow to the flood plain (e.g., the City of Ferndale), are not in a Lummi wellhead protection area. Although there are areas on the flood plain where fresh water may be perched above salty ground water or directly overlie salty ground water, in general the flood plain is not suitable for ground water development (Cline 1974). Currently, there are no known uses of this ground water for domestic supply.

Because the Reservation is located in a coastal area and most of the existing water supply wells are within a half mile of marine waters, salt water intrusion is a major threat to the Lummi Nation's ground water resources. Available evidence suggests that the fresh ground water resources underlying the Reservation consist of a lens that overlies salt water. These conditions indicate that protection is required for both vertical and lateral migration of seawater. Several public water supply wells in the Gooseberry Point area have been closed due to progressive salt water intrusion induced by overpumping of nearshore wells. The ground water found in numerous other areas on the Reservation is too saline for most uses.

In addition to salt water intrusion, the ground water resources are vulnerable to contamination from agricultural, residential, municipal, commercial, and industrial land uses. In Area 1, the greatest potential threats to the ground water supply (after salt water intrusion) include: horses and goats fenced within residential areas near Hermosa Beach, single family residential units relying on private water supply wells and/or septic systems, and an abandoned landfill along Chief Martin Road. In Area 2, the greatest potential threats to the ground water supply (after salt water intrusion) include: single family residential units relying on private water supply wells and/or septic systems, roadways (i.e., transportation corridors for the Cherry Point Heavy Impact Industrial Zone), manure lagoons, and the Tosco petroleum oil refinery located directly north of the Reservation boundary.

Using current water price information and a simplified equation, it was estimated that importing water from the City of Bellingham costs about four times what it costs to obtain water from local wells. Rates would have to be raised an average of about $2.26 per month for the 485 current residential customers of the Lummi Water District for every 20 gpm of lost pumping capacity. Based on the observed pumping rates in Lummi Water District supply wells, 20 gpm is equivalent to about one well.

The simplified equation used to estimate the water replacement cost does not address the cost to the Lummi Nation of depleting a ground water resource in a region with a limited water supply. It is impossible to put a true value on a resource that is essential to life, is finite, and is irreplaceable. For the Lummi Nation, ground water is also culturally significant as a component of the natural environment.

The monetary value of an alternative water supply computed using the simplified equation also does not address the impacts to the Nooksack River fisheries resources that could result from any increased diversions necessary to supply the water, the broad economic impacts of the restriction of future tribal development by reduced water availability, and the reduction in the potential supply of the Bellingham pipeline resulting from its use to import water that was formerly obtained from local ground water wells. The replacement costs would be much greater if the salmon hatchery supply well became unusable and it became necessary to identify and develop an alternative source of non-chlorinated water.

Although the future cost to replace the water supply was not quantified, it is apparent that future water demands on the Reservation could triple in the next 10 to 20 years if the tribal demands for residential housing, commercial development, and institutional expansion are achieved. The locally available ground water resources will not be adequate to meet the future water demand and water will likely need to be imported. It is important to protect the Reservation wellheads to minimize the amount of purchased water.

Because ground water movement does not follow private property or political boundaries, and because community participation in developing and implementing the management plan is necessary for a successful program, community involvement is a critical element of a wellhead protection program. The two elements of the community involvement plan are 1) public education and, 2) interjurisdictional coordination and cooperation for activities off-Reservation that affect on-Reservation ground water resources. The community involvement plan, spill response planning, and the development of wellhead protection measures will be implemented in the coming months.

1. INTRODUCTION

The overall purpose of the Lummi Nation Wellhead Protection Program is to protect wellhead areas within the Reservation ("Reservation") from contaminants which may have any adverse effect on the health of persons or on the integrity of the ground water resources of the Lummi Nation. The wellhead protection program is a proactive approach by the Lummi Nation to prevent contamination of ground water resources by pollution and to reduce the risks that the Lummi Nation's ground water resources will become impaired or otherwise unusable as the primary water supply for the Lummi Nation and residents of the Reservation.

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As listed below, major components of the Lummi Nation's Wellhead Protection Program will include a susceptibility assessment, a contingency plan, community involvement, spill response planning, and the development of protection measures. The three components completed as part of Phase I are the susceptibility assessment, contingency plan, and community involvement plan. The community involvement plan will be implemented now that the largely technical components of the program are completed. The spill response planning and development of protection measures will occur as the community involvement plan is implemented.

- **Susceptibility Assessment:** The purpose of the susceptibility assessment is to evaluate the vulnerability of ground water wells to contamination. Key elements of this assessment are a description of the hydrogeologic setting, an inventory and characterization of ground water wells on and adjacent to the Reservation, delineation of wellhead protection areas, and an inventory of potential ground water contaminant sources in each wellhead protection area.

- **Contingency Planning:** A contingency plan is an analysis of water supply replacement options and associated costs. The purpose of a contingency plan is to prepare for an emergency that would render a portion of the water supply unusable.

The estimated cost to replace the existing water supplies also helps define the economic context of any proposed wellhead protection measures. That is, although a wellhead protective measure may have associated costs, the true economic cost of the protective measure should be evaluated in light of the replacement cost of the water source. This knowledge can help elected leaders justify the protective measure(s) to their constituents.

- **Community Involvement:** Community involvement is a critical element of a wellhead protection program and will be solicited in the coming months. The community involvement phase will consist of a public education element and solicitation of interjurisdictional coordination and cooperation. Articles will be presented in the Lummi Nation newspaper *Squol Quol*, and a slide presentation about the program will be provided to interested groups and to the various Lummi Indian Business Council (LIBC) commissions. In accordance with LIBC policies and procedures, public hearings will be conducted prior to adoption of any new ordinances identified as protective measures.

- **Spill Response Planning:** Spill response plans are developed to minimize damage to an aquifer resulting from a spill of hazardous material in a wellhead protection area. The spill response planning consists of a review of existing spill response procedures and modification or development of new procedures as necessary for the wellhead protection areas. The spill response plan will be developed in the coming months in coordination with local emergency responders (e.g., law enforcement, fire department, Cherry Point industries).

- **Development of Protection Measures:** Defining and implementing effective wellhead protection measures is the primary means to achieve the program goal of preventing ground water contamination. Wellhead protection measures may include land use ordinances, permit review requirements (e.g., requirements that consideration be given to all potential contaminant sources within the expected wellhead area of new water wells), standards for new industry and businesses, purchase of property, water conservation, household hazardous waste collection, public education initiatives, spill response planning, decommissioning abandoned wells or wells not intended for future use, and similar activities.

The purpose of this Phase I report on the Lummi Nation Wellhead Protection Program is to: 1) present the susceptibility assessment results, 2) describe the replacement options for the existing water supply and associated costs, and 3) present the public involvement plan that will be implemented in the coming months.

A Phase II report documenting the status of the Lummi Nation Wellhead Protection Program will be completed in March 1998. The Phase II report will document the implementation of the community involvement plan, the spill response planning effort, and the development of protection measures. The Phase II report will also identify the 1998-2000 action plan for the Lummi Nation Wellhead Protection Program.

This Phase I report is organized into eight sections and three appendices. The eight sections of the report are:

- Section 1 is this introductory section.
- In Section 2, wellheads on the Reservation are described.
- In Section 3, the methods used to delineate wellhead protection areas are reviewed and the Lummi wellhead protection areas described.
- In Section 4, inventories of potential contaminant sources and associated potential contaminants in each wellhead protection area are presented.
- In Section 5, an analysis of water supply replacement options and associated costs is presented.
- In Section 6, the community involvement plan for the wellhead protection program is described.
- In Section 7, the Lummi Nation Wellhead Protection Program plan is summarized.
- References used in the program development are listed in Section 8.

Sections 2 through 4 comprise the susceptibility assessment for the Lummi Nation Wellhead Protection Program. Section 5 is the contingency plan for the program, and Section 6 is the community involvement plan.

An inventory of wellheads, test holes, and undeveloped springs on and near the Reservation is presented in Appendix A. Appendix B is a draft of the first article that will be submitted for publication in the *Squol Quol* as part of the public education element of the community involvement plan. A slide presentation that will be used to explain the program is outlined in Appendix C. This slide presentation will be used for both the public education and the interjurisdictional coordination and cooperation elements of the public involvement plan.

2. LUMMI RESERVATION WELLHEADS

A wellhead is a physical structure, facility, or device at the land surface from or through which ground water flows or is pumped from water-bearing formations (i.e., aquifers). A wellhead can be a developed spring or a ground water well that was hand dug or constructed by machine.

To evaluate the vulnerability of wellheads to contamination, information is needed about:
1. Topography and climate,
2. Hydrogeologic conditions,
3. Locations and characteristics of nearby wellheads,
4. Water sources for the wellheads,
5. Methods that can be used to define and map wellhead protection areas, and
6. Potential contaminants that could make the ground water resources unusable.

This section describes the topography and climate, the hydrogeologic conditions of the Reservation, a wellhead inventory, and the wellhead characteristics. In the sections that follow, the wellhead protection areas are identified and an inventory of potential contaminant sources in the mapped areas is presented.

2.1 TOPOGRAPHY AND CLIMATE

The approximately 12,500 acre Lummi Reservation has two relatively large upland areas and a smaller upland area on Portage Island (Figure 2.1). The maximum elevation of the northern upland area is about 220 feet above mean sea level (ft msl). The southern upland area is the Lummi Peninsula with a maximum elevation of about 180 ft msl. The maximum elevation on Portage Island is about 200 ft msl. The flood plains of the Lummi and Nooksack rivers, with an average elevation of approximately 10 ft msl, lie between the northern upland and the Lummi Peninsula. The Nooksack River flood plain and the Nooksack River delta are located along the northeastern extent of the Lummi Peninsula upland.

The two relatively large upland areas are drained by short, intermittent streams and numerous springs both above and below the line of ordinary high water. These streams and springs discharge into either Bellingham Bay, Hale Passage, Lummi Bay, Georgia Strait, or to the flood plain of the Lummi and Nooksack rivers. An inventory of storm water facilities on the Reservation indicates that at least 45 culverts on the Reservation discharge storm water directly to marine waters or to the flood plain. The flood plain of the Lummi and Nooksack rivers is drained by a network of agricultural drainage ditches and the Lummi and Nooksack rivers.

The drainage on Portage Island consists of at least two intermittent streams that drain northward to Portage Bay. Springs along the upland areas of Portage Island and below the line of ordinary high water also discharge to marine waters.

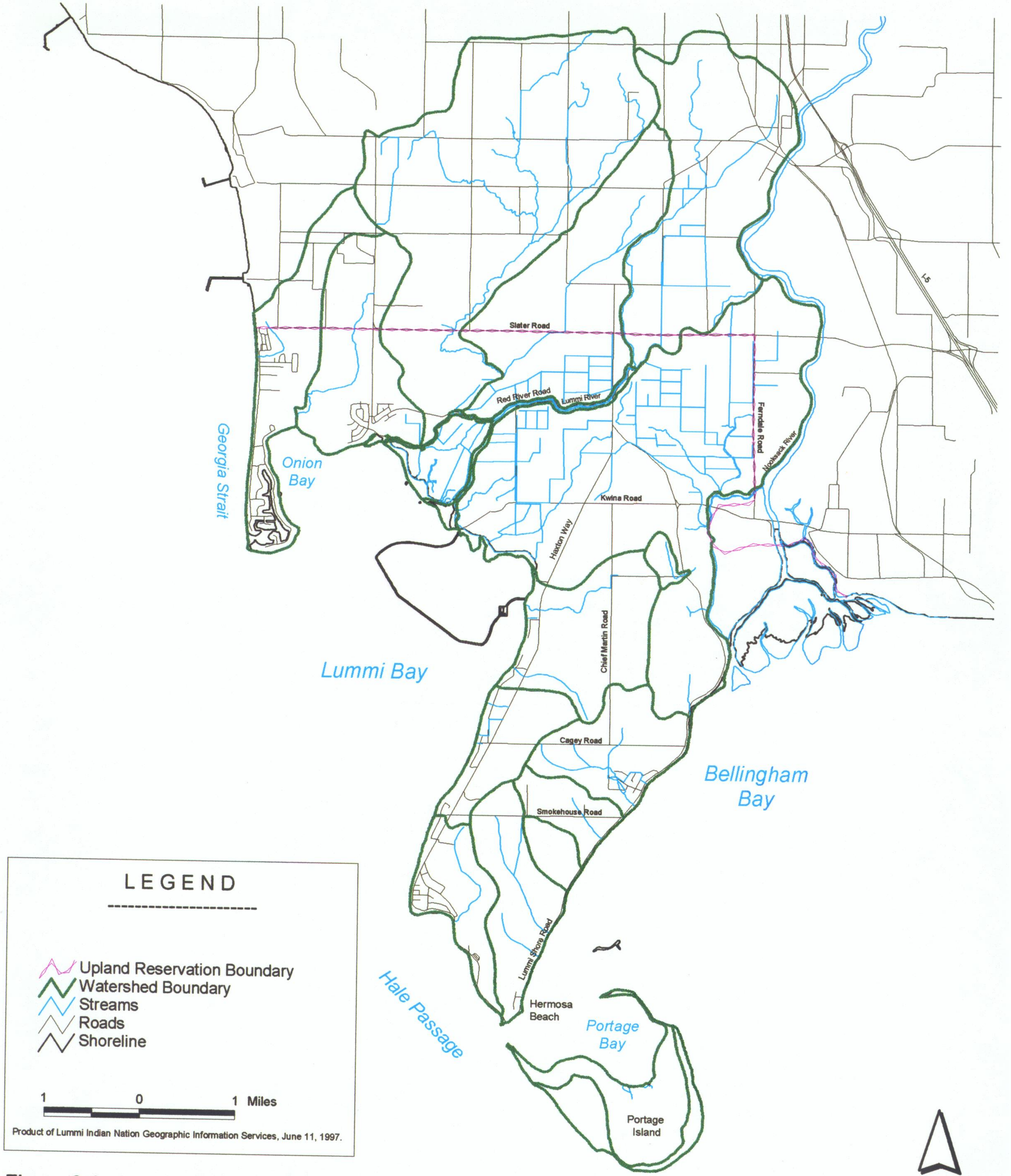

Figure 2.1 - Lummi Reservation Hydrography.

Although ground water recharge may occur as a result of infiltration from surface water sources (e.g., intermittent streams), precipitation is the source of virtually all fresh ground water on the Reservation (Cline 1974). Based on climate data collected at the Bellingham Airport, the average annual precipitation over the 1960-1990 normal period is approximately 36.2 inches. November, December, and January are the wettest months; June, July, and August are the driest months. About 81 percent of the average annual precipitation occurs during the October through May period; about 19 percent of the average annual total occurs from June through September.

Temperature data collected at the Bellingham Airport over the 1960-1990 period indicate that the warmest months are July and August. During these months the average maximum daily temperature is approximately 71 degrees Fahrenheit (°F). December and January are the coldest months. During December and January the average minimum daily temperature is about 32°F.

Evapotranspiration has not been measured on the Reservation but has been estimated. Phillips (1966) estimated the average annual actual evapotranspiration for a 6-inch water holding capacity soil at the Marietta 3 NNW station to be approximately 18.8 inches. This estimate represents about 52 percent of the mean annual precipitation.

Because most of the precipitation occurs during the winter months when evapotranspiration demand is low, most of the ground water recharge occurs during this season. After the rainy season and during the summer months when evapotranspiration demand is high, little water is available for downward percolation and recharge of the aquifer.

2.2 HYDROGEOLOGIC CONDITIONS

The hydrogeologic conditions on the Reservation have been described previously by the USGS and others (Washburn 1957, Cline 1974, Easterbrook 1973, Easterbrook 1976). In general, the Reservation is underlain by unconsolidated sediments deposited as glacial outwash, glaciomarine drift, glacial till, and flood plain or delta deposits of Quaternary age (Washburn 1957). The unconsolidated deposits consist of clay, silt, sand, gravel, and boulders. Because the composition of the deposits commonly change laterally over short distances, it is difficult to distinguish between the different stratigraphic units from existing well log data.

Ground water is obtained primarily from sand and gravel outwash deposits in the unconsolidated sediments. Glaciomarine drift is at or near the ground surface over much of the upland areas on the Reservation. The glaciomarine drift contains substantial amounts of clay which restricts the recharge to the underlying aquifer.

2.2.1 Geology

The sediment units and associated water-yielding properties described by Cline (1974) and Easterbrook (1976), in order from youngest to oldest, are summarized below.

- **Alluvium:** The alluvium is derived from sediment carried by the Lummi and Nooksack rivers and deposited on the flood plain. It is comprised mostly of clay, silt, sand, and some gravel. Wells tapping the alluvium generally yield less than 5 gallons per minute (gpm), although larger yields are possible from the sand and gravel zones.

- **Beach Deposits:** The beach deposits are laid down by littoral drift processes. The deposits are mostly sand with some gravel and occur mainly at the western part of the Reservation from Neptune Beach to Sandy Point and at Gooseberry Point. Wells tapping the beach deposits generally yield from less than 1 to 10 gpm of fresh ground water. In other areas, wells tapping this deposit yield salty water that either occurs naturally or may be induced by pumping.

- **Older Alluvium:** The older alluvium was deposited by the Lummi and Nooksack rivers when the valley floor was relatively higher than at present. The unit consists mostly of fine sand with some silt and clay located on stream terraces flanking the uplands above the flood plain. These deposits occur along the southeast flank of the Mountain View Upland and the northeast flank of the Lummi Peninsula. Where saturated zones are encountered, wells tapping this unit generally yield less than 5 gpm.

- **Gravel:** A thin unsaturated gravel unit is exposed at the surface at several locations on the Reservation. The unit consists of gravel and sand/gravel. In places, this unit appears to have been reworked by beach processes during post-glacial uplift and overlies glaciomarine drift. In other places, this unsaturated unit appears to overlie or be a part of the Esperance Sand unit and cannot be distinguished from the lower unit in the well records.

- **Glaciomarine Drift:** The Glaciomarine Drift unit was deposited late in the Fraser Glaciation (from about 20,000 years ago to about 10,000 years ago [Easterbrook 1973]). The drift is comprised of unsorted clay, silt, sand, gravel, and some cobbles and boulders. The deposits include both Kulshan and Bellingham drifts and generally yield little water. Limited sand and gravel lenses may contain small amounts of perched ground water. Wells can yield from less than 1 to 5 gpm from this unit.

- **Glacial Till:** The glacial till from the Vashon Stade of the Fraser Glaciation is comprised of poorly sorted clay, silt, sand, gravel, and some cobbles and boulders. The till deposits generally yield little or no water as till has a compact and concrete-like texture. Because the presence of till is noted in only a few well logs and has been observed at only a few locations along the Lummi Peninsula bluffs, the occurrence of till is believed to be limited.

- **Esperance Sand:** The Esperance Sand unit (Easterbrook 1976), formerly named Mountain View Sand and Gravel, is advance outwash comprised of stratified beds of sand and gravel with stratified lenses of sand. The unit overlies the Cherry Point Silt unit and underlies the glaciomarine drift and till; it is the major water yielding unit beneath the Reservation. Wells tapping this unit commonly yield more than 20 gpm and can yield as much as 400 gpm.

- **Cherry Point Silt:** The Cherry Point Silt unit is the oldest known unconsolidated stratigraphic unit in the northern Puget Sound lowland. This unit is comprised of a thick sequence of blue to brownish gray stratified clay and silt with minor sandy beds. Wells tapping the water-bearing sand beds yield mostly from less than 1 to 5 gpm.

- **Bedrock:** Bedrock underlying the Reservation consists mostly of sedimentary rocks such as sandstone, siltstone, shale, and conglomerate. The bedrock is deeply buried by unconsolidated glacial deposits. No water is obtained from the bedrock on the Reservation.

2.2.2 Ground Water Occurrence

Two apparently separate ground water systems occur on the Reservation. One system is located in the northern upland area. This system flows onto the Reservation from the north and drains to the west, south, and east. The second ground water system is located in the southern upland area of the Reservation known as the Lummi Peninsula. This system is completely contained within the Reservation boundaries. The flood plain of the Lummi and Nooksack rivers separate the two larger systems.

In general, both the northern and southern ground water systems contain two aquifer layers (Washburn 1957, Easterbrook 1976). The upper aquifer layer is comprised primarily of glaciomarine drift containing lenses of sand or sand and gravel. These relatively permeable lenses are not continuous throughout the area. The pebbly clay in the drift sediments and scattered deposits of till greatly slow the downward percolation of water to the lower aquifer. The lower aquifer layer is comprised of advance outwash sand and gravel. The thickness of the lower aquifer, which appears to be semi-confined in places and unconfined in other places, is not known.

Upland springs, which are commonly ground water discharge zones for the shallow perched aquifers, occur throughout the Reservation. When water moving downward in the permeable sand or sand and gravel lenses encounters the relatively impermeable clay, it moves laterally along the top of the clay layer until the layer intercepts the land surface. A seep or spring occurs at the interception point and wetlands occur if the interception point is a topographic depression. In addition to upland springs, springs occur along the shoreline below the ordinary high water line at numerous locations on the Reservation.

2.3 WELLHEAD INVENTORY

Wellheads and/or the ground water resources on the Reservation have been inventoried by the U.S. Geological Survey (USGS) and others on several occasions since the late-1940s (Newcomb et al. 1949, Washburn 1957, Cline 1974, Charles Howard and Associates 1991, Golder 1992, and Drost 1996). The information from these inventories, along with information collected by the Lummi Natural Resources Department Water Resources staff since 1991, was used to identify the wellhead locations on the Reservation. In addition, information from the previous USGS work and well logs obtained from the Washington State Department of Ecology were used to identify the locations of wells north of the Reservation in the watersheds that contribute surface water to the Reservation. These wells located beyond the exterior boundaries of the Reservation were inventoried because they may share an aquifer serving the Reservation.

Two separate numbering systems are used to identify wellheads on the Reservation. The primary wellhead identification system is a simple numbering system that starts with the number 1. This system builds on the work of Cline (1974). Wells numbered 1 through 99 were inventoried by Cline (1974). The 19 test holes drilled in 1956 (Washburn 1957) and wells constructed or identified after the 1971 inventory conducted by Cline have a local identification number greater than 99. The second wellhead identification system is the system used by the USGS. Both systems were used so that the well information is interchangeable between the USGS and the Lummi Natural Resources Department.

The USGS wellhead identification system is based on the wellhead location within a township, range, and section. For example, a well located along Lummi View Drive south of the MacKenzie Road intersection could have the identification number 37N/01E-03H01. This identification number indicates that the well is in Township 37 north of the Willamette base line (37N), in Range 1 east of the Willamette meridian (01E), and in Section 3 within the township (03). The letter following the section number ("H") indicates the quarter-quarter section (40-acre) that contains the well. The number following the letter (01) is the sequential number of the wellhead within the 40-acre subsection. The letters "S" or "D" following the sequence number indicates respectively that the wellhead is either a spring or a deepened well. This location-based numbering system is illustrated in Figure 2.2.

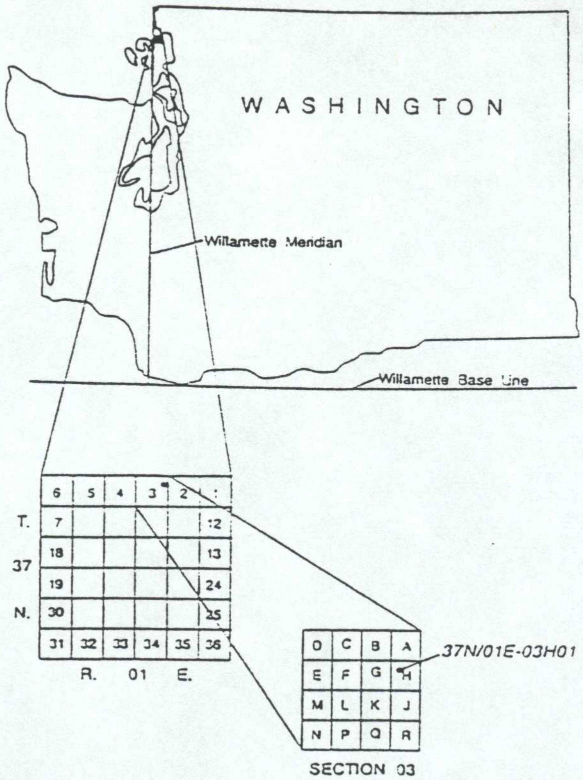

Figure 2.2 Well-numbering system used by the USGS in Washington

A database about Reservation wellheads was developed using information provided by the USGS, information from well logs, and information collected by the Lummi Water Resources Division. The database currently contains the following fields:

1. Lummi Number (local identification number)
2. Location (USGS identification number)
3. Owner (owner identified on well log or current owner if known)
4. X Coordinate (UTM coordinate (X-axis) in meters)
5. Y Coordinate (UTM coordinate (Y-axis) in meters)
6. Z Coordinate (elevation of wellhead in feet above mean sea level [msl])
7. ZM Coordinate (elevation of well water level measurement point in feet)
8. Site Use (primary site use [e.g., withdrawal, destroyed, unused, standby or emergency, unknown])
9. Water Use (primary use of water [e.g., public supply, domestic, irrigation, test well, fish propagation, unused or destroyed, commercial, municipal, industrial, stock watering, other])
10. Tribal Owner (is the well owned by a Lummi Indian [yes or no]
11. Chemical Data (chloride data, chloride and other data, or no chemical data)
12. Pump Test (pump test conducted using nearby monitoring wells [yes or no])
13. Active (is the well actively being used [yes or no])
14. Monitor (is the well in the Lummi Natural Resources monitoring program [yes or no])

15. Reservation (is the well located on the Reservation [yes or no])
16. Accuracy of the Z Coordinate (accuracy of the elevation data in feet)
17. Field Visit (well has been visited in the field)
18. Latitude (latitude of wellhead)
19. Longitude (longitude of wellhead)
20. Accuracy of Latitude and Longitude coordinates
21. Depth of the hole drilled for the well (feet)
22. Depth of the completed well (feet)
23. Well log on file with the LIBC (yes or no)
24. Driller (well driller)
25. Year well drilled or dug.

New fields, such as well diameter, screen size and type, length of casing, specific capacity, and watershed identification will be added to the database as time allows. Similarly, additional wells north of the Reservation were identified from well logs and will be incorporated into the database as time allows. This database of wellhead characteristics is linked to separate databases that contain information from the Lummi Natural Resources Department's well monitoring program and from other water quality testing.

The wellhead inventory is presented in Figure 2.3 and in Appendix A. As of February 1997, a total of 220 wellheads, test holes, and undeveloped springs were identified within the exterior boundaries of the Reservation. Of these 220 wellheads, test holes, and springs, 79 wellheads (36 percent) are currently used for water supply, the use status of 9 wellheads (4 percent) is not known, and the remaining 132 wellheads, test holes, or springs (60 percent) are either no longer used or were never used. Additional wells north of the Reservation, test pits associated with an Indian Health Services scattered sites program, and numerous springs located along the upland areas and seaward of the ordinary high water line have not been mapped yet. As can be seen in Figure 2.3, most of the water supply wells on the Reservation are concentrated in areas near the shoreline.

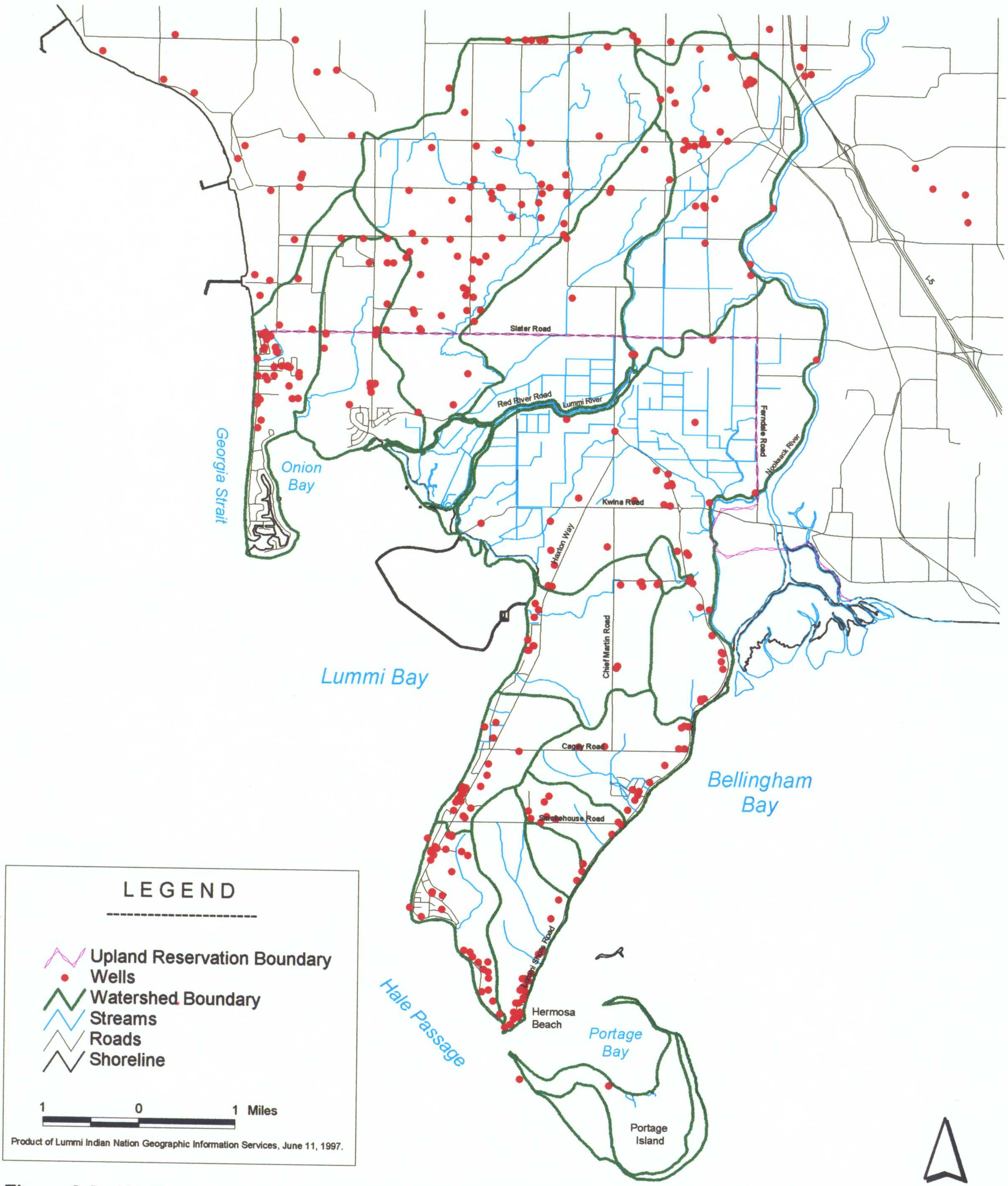

Figure 2.3 - Wellheads of the Lummi Reservation and Adjacent Uplands.

2.4 WELLHEAD CHARACTERISTICS

Well logs are available for 157 of the 220 wellheads, test holes, and springs on the Reservation (71 percent). As possible, information from the available well logs and field measurements were used to determine the depth of the completed wells. The well logs, topographic maps, and published land surface elevation data (Cline 1974) were used to determine the land surface elevation of the Reservation wellheads. The land surface elevation of wells inventoried by the USGS in 1971 (Cline 1974) were reportedly surveyed and are believed to be accurate to ± 0.1 foot. The Lummi Water Resources staff also surveyed the elevation of several wells on the Reservation. Elevation data determined from topographic maps are believed to be generally accurate to about ± 10 feet.

To determine the number of wells completed below the elevation of mean sea level (ft msl), the well depth was subtracted from the land surface elevation. Of the 220 wellheads, test holes, and undeveloped springs in the on-Reservation wellhead inventory, 151 (69 percent) were completed below mean sea level, 45 (20 percent) were completed above mean sea level, and the depth of the completed wells relative to mean sea level is unknown for 24 wells (11 percent). Although the completed well depth relative to the mean sea level may be inaccurate in some cases (due to inaccuracies in the land surface elevation data or in the well depth data), the data indicate that approximately two-thirds of the inventoried wells on the Reservation are completed below sea level.

Of the 88 wells that are still currently used for water supply (79 known wellheads, 9 wellheads with an unknown use status), 74 wells (84 percent) are completed below mean sea level, 5 wells (6 percent) were completed above mean sea level, and the depth of the completed well relative to mean sea level is unknown for 9 wells (10 percent).

As reported by Cline (1974), ground water is generally obtained from sand or sand and gravel deposits. Most of the wells tap the water-bearing deposits which are located below clay layers. The clay layer can range in thickness from 2 feet (e.g., Well No. 56) to over 100 feet in places (e.g., Well No. 115). The thick clay layer affords a level of ground water protection if it is immediately around the well but likely thins where the aquifer is recharged. Although the protective clay deposits are present where many of the wellheads are located, there are several wells (e.g., Well No. 127) in which the clay layer is absent.

The ground water yield of wells on the Reservation is generally low and can vary over short distances. As described in the overview of the Reservation geology, ground water wells on the Reservation generally yield from less than 1 gallon per minute (gpm) to approximately 60 gpm (Cline 1974). The highest yield reported on the southern upland area (i.e., Lummi Peninsula and Portage Island) is about 60 gpm. There is a limited area in the western section of the northern upland area of the Reservation where higher yields have been encountered. Three wells with reported yields greater than 200 gpm are located near the southeastern corner of Neptune Circle. Although these three wells have relatively high yields, the yields reported for three wells near the western side of Neptune

Circle (approximately 0.1 mile distance) range from 25 gpm to 30 gpm. Wells located approximately 0.25 miles to the east were not productive.

3. LUMMI WELLHEAD PROTECTION AREAS

A wellhead protection area is the area managed by a community to protect ground water sources of drinking water. As defined in the Safe Drinking Water Act (SDWA), wellhead protection areas are the surface and subsurface areas surrounding a water well or wellfield, supplying a public water system, through which contaminants are reasonably likely to move toward and reach such water well or wellfield. A contaminant is defined in the SDWA as any physical, chemical, biological, or radiological substance or matter in water. In addition to a sanitary control area immediately around a wellhead (100 feet radius around a well, 200 feet radius around a spring), in general a wellhead protection area includes the area that contributes water to a well or spring over a 1 to 10 year period.

There are several technical criteria that can be used as the basis for delineating wellhead protection areas. In addition, there are several methods available to implement the criteria and map the protection areas. The technical criteria for delineating the wellhead protection areas are presented briefly in this section of the plan, followed by a summary of the available methods for delineating wellhead protection areas. Finally, the criteria selected to delineate the wellhead protection areas for the Lummi Nation Wellhead Protection Program is discussed and a map of the Lummi wellhead protection areas presented.

3.1 WELLHEAD PROTECTION AREA DELINEATION CRITERIA

The EPA (1987) recommends five technical criteria that can be used as the basis for delineating wellhead protection areas. The technical criteria and associated considerations are the following (EPA 1987):

- **Distance:** The distance criteria is the simplest, least expensive, and most direct method to delineate a wellhead protection area. In essence, a specific distance from a well is selected based on past experience with ground water pollution control or on non-technical considerations. The selected distance is used as the radius for a circle that is drawn around the wellhead to delineate the protection area. This approach is only recommended as a preliminary step since it does not include the processes of ground water flow or contaminant transport.

- **Drawdown:** Drawdown is the decline in ground water elevation caused by a pumping well. The greatest drawdown occurs at the well and decreases with distance away from the well until an outer limit is reached where the water level is not affected by the pumping. This outer limit marks the areal extent of the cone of depression around the well. This area of influence can be used as a wellhead protection area.

- **Time of Travel:** The time of travel criterion is used to represent the time required for ground water or a contaminant to flow from a point within the area of contribution to the well. Using this criterion, contours of equal times of travel (i.e., isochrons) for selected time periods (e.g., 1-, 5-, and 10-years) are delineated on a map and the areas enclosed by the isochrons used as wellhead protection areas.

- **Flow Boundaries:** The flow boundary approach uses the locations of ground water divides and/or other physical and hydrologic features that control ground water flow to define the geographic area that contributes ground water to a pumping well. This area of contribution is used as the wellhead protection area. This approach assumes that contaminants entering the area of contribution will eventually reach the pumping well. This method can be interpreted as the most protective approach; it is especially appropriate for aquifers less than 10 to 20 square miles in area.

- **Assimilative Capacity:** The assimilative capacity approach takes into account the fact that through processes of dilution, dispersion, adsorption, chemical precipitation, and biological degradation, the saturated and/or unsaturated sections of an aquifer can reduce the toxicity of contaminants before they reach a pumping well. This approach requires knowledge of contaminant transport modeling, and extensive information on the hydrology, soils, geology, and geochemistry of the study area.

The technical merits of the different criteria depend on how well the criterion represents the processes that affect ground water flow and contaminant transport (EPA 1987). As noted above, the distance criterion does not represent the processes of ground water flow or contaminant transport. The drawdown and the flow boundaries criteria only represent the physical processes controlling contaminant movement due to ground water flow (i.e., advection). These two criteria do not represent mechanical dispersion and molecular diffusion (i.e., hydrodynamic dispersion) nor do they represent adsorption and chemical reactions (i.e., solid-solute interaction) that may occur to the contaminant as it moves through the ground water system. The time of travel criteria can consider the processes of advection, hydrodynamic dispersion, and solid-solute interaction. The assimilative capacity approach considers hydrodynamic dispersion and solid-solute interaction but does not represent advection.

Conceptually, the time of travel wellhead protection area delineation criteria incorporates a more comprehensive evaluation of the physical processes of contaminant transport than most of the other identified criteria. As advection is the best understood of the physical processes that affect contaminant transport, time of travel calculations for wellhead protection area delineations are usually based on advection. The time of travel delineation criteria is used by the Washington State Wellhead Protection Program.

3.2 WELLHEAD PROTECTION AREA DELINEATION METHODS

At least six methods exist for delineating the boundaries of wellhead protection areas. The methods and associated technical criteria applied are listed below in order of increasing complexity and accuracy (EPA 1987, EPA 1993):

- **Arbitrary Fixed Radius Method:** The arbitrary fixed radius method is an application of the distance criteria for delineating wellhead protection areas. The arbitrary fixed radius method involves drawing a circle with a specified radius around each well. The radius length should reflect the hydrogeology of the area. The advantage of this method is that minimal data are necessary, it is quick and easy to draw a circle around a well, and the method can be implemented at low cost. The disadvantage is that it is not very accurate.

- **Calculated Fixed Radius Method:** The calculated fixed radius method is an application of the time of travel criteria. The calculated fixed radius method involves drawing a circular boundary around a well for a specified time of travel. The radius of the circle is calculated using an equation that relates the pumping rate of the well, the aquifer porosity, the well screen length, and the time of travel to the well. The time of travel is chosen based on hydrology and the location of contaminant sources. The advantage of this method is that limited hydrogeologic data are required, it is relatively quick and easy, and is inexpensive to implement. The disadvantage is that it is not highly accurate.

- **Simplified Variable Shapes Method:** The variable shapes method is an application of the flow boundaries and time of travel criteria. The simplified variable shapes method uses analytical computer models to produce "standardized forms" of wellhead protection areas using representative hydrogeological criteria, time of travel, and the locations of physical or hydrologic features controlling ground water flow. The most suitable standardized shape is selected for each well by determining how closely the form matches the hydrogeologic and pumping conditions at the wellhead. The standardized form is aligned around the wellhead based on the direction of ground water flow. The advantage of this method is that it is based on relatively little field data, it is still fairly quick and easy, and it can be accomplished at low cost if the data are available. The disadvantage is that it is not very precise in complex settings.

- **Analytical Methods:** The analytical methods are an application of the time of travel criteria. The analytical methods involve the use of mathematical equations to calculate the boundaries of wellhead protection areas. The calculations are generally performed using computer models. Hydrogeologic data such as hydraulic conductivity, transmissivity, hydraulic gradient, angle of ambient flow, aquifer porosity, pumping rate, and saturated zone thickness are required as input to the models. Advantages of the method are that the equations are generally easily understood and solved, and the models take into account some site-specific hydrogeologic parameters. Disadvantages of the method are that aquifer heterogeneities and non-uniform rainfall, evapotranspiration, or infiltration over the contributing area are not represented.

- **Hydrogeologic Mapping:** The hydrogeologic mapping method uses geological, geophysical, and dye tracing methods to apply the flow boundaries and time of travel criteria. The flow boundaries are defined by variations in lithology or contrasts in permeability within the aquifer. Ground water levels may also be mapped to identify ground water drainage divides. The advantage of the hydrogeologic mapping method is that it is well suited to hydrogeologic settings dominated by near-surface flow boundaries as are found in many glacial and alluvial aquifers with high flow velocities. Disadvantages of the method are that it requires specialized expertise in geologic and geomorphic mapping and substantial judgment on what constitutes likely flow boundaries. The method is less suited for delineating wellhead protection areas in large or deep aquifers.

- **Numerical Flow/Transport Models:** The numerical flow/transport models are computer models that mathematically approximate ground water flow and/or solute transport. The models can map the drawdown, flow boundaries, and time of travel delineation criteria. The method typically uses a two-step approach. First, a hydraulic head distribution grid is generated with a numerical flow model under a prescribed set of hydrogeologic parameters and conditions. Second, a numerical solute transport model that uses the generated grid as input computes the wellhead protection area based on preselected criteria. These models are particularly useful for delineating wellhead protection areas where boundary and hydrogeologic conditions are complex, where the necessary data are available and accurate, and the hydrogeology of the area is known. The advantage of this method is that it provides a very high potential degree of accuracy and can be applied to nearly all types of hydrogeologic settings. The disadvantage of this method is that a considerable amount of technical expertise and accurate data are required, and the costs of applying the method are relatively higher than the others.

3.3 DELINEATION OF LUMMI WELLHEAD PROTECTION AREAS

After considering the wellhead protection area criteria, the available methods, the local hydrogeology, the available hydrogeologic data, the wellhead inventory, the wellhead characteristics, the threat of lateral and vertical salt water intrusion, and the occurrence of ground water on the Reservation, the flow boundaries criteria was selected as the technical basis for delineating wellhead protection areas in the Lummi Nation Wellhead Protection Program. The method used to apply the flow boundaries criteria was the hydrogeologic mapping method. Available hydrogeologic mapping (Cline 1974) and 1:24,000 scale USGS topographic maps were used to identify likely flow boundaries.

The flow boundaries criteria was selected as the most appropriate approach for the Lummi Wellhead Protection Program for several reasons including:

1. The flow boundaries approach is the most protective criteria.
2. Both public supply wells and private domestic supply wells of Reservation residents are included in the wellhead protection program.
3. Detailed hydrogeologic data are not available for most locations on the Reservation; in the northern upland area, the extent of the aquifer has not been determined.
4. The hydrogeologic conditions on the Reservation vary considerably over short distances.
5. The approach is well suited to hydrogeologic settings dominated by near-surface flow boundaries as are found in many glacial and alluvial aquifers.
6. The Reservation aquifers are believed to be less than 10 square miles in area.

7. The applicability of the time to travel criteria is limited because the time of travel to Reservation wellheads is likely less than 1 to 10 years.

3.4 LUMMI WELLHEAD PROTECTION AREAS

The two wellhead protection areas identified in the Lummi Wellhead Protection Program are shown in Figure 3.1. Area 1 is located on the Lummi Peninsula and incorporates most of the southern upland area. Portage Island is included in Area 1. Area 2 is located at the northwestern part of the Reservation. This area encompasses the northern upland area of the Reservation and extends up to about 3 miles north of the Reservation boundary.

The flood plain of the Lummi and Nooksack rivers, as well as areas north of the Reservation that contribute flow to the flood plain (e.g., the City of Ferndale), are not in a Lummi wellhead protection area. Although there are areas on the flood plain where fresh water may be perched above salty ground water or directly overlie salty ground water, in general the flood plain is not suitable for ground water development (Cline 1974). Currently, there are no known uses of this ground water for domestic supply.

The northern extent of Area 1 corresponds to the northern extent of a area of fresh ground water in surface deposits identified by the USGS (Cline 1974) in a map showing areas of fresh and salty ground water on the Reservation (Figure 3.2). Area 1 is approximately 6,625 acres in size (10.4 mi^2) and encompasses locations where fresh ground water was historically found to all depths penetrated by wells, a transition area where fresh ground water is adjacent to salty water or where salt water is encountered in places, and an area where salt water has been encountered (Cline 1974). The precise locations of the boundaries for these areas and the hydrogeologic relations between them are unknown due to a lack of data. Area 1 was extended to the north into an area where saline water was encountered in order to encompass and protect wells that obtain fresh water from surface deposits along the northern and northeastern extents of the Lummi Peninsula.

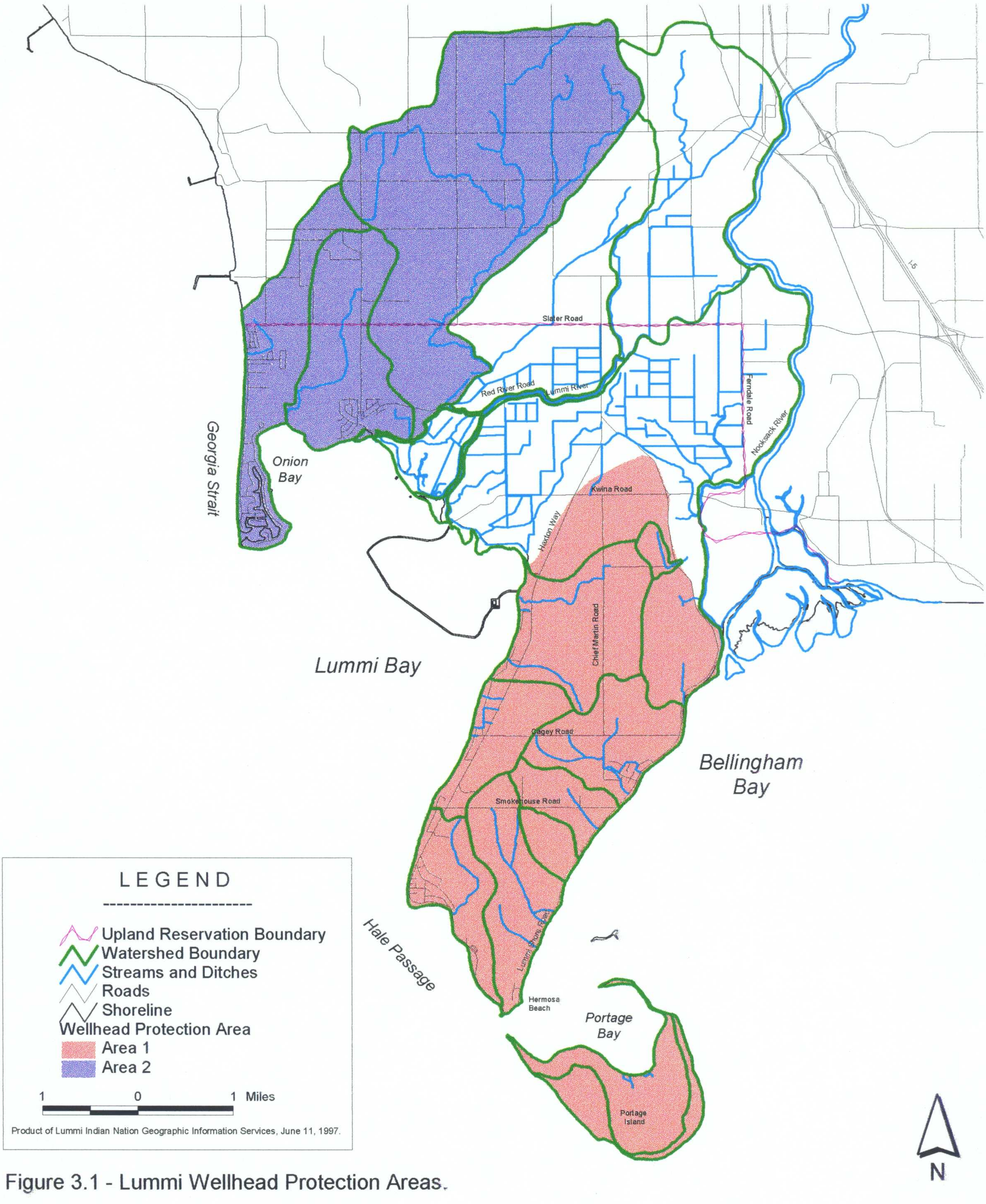

Figure 3.1 - Lummi Wellhead Protection Areas.

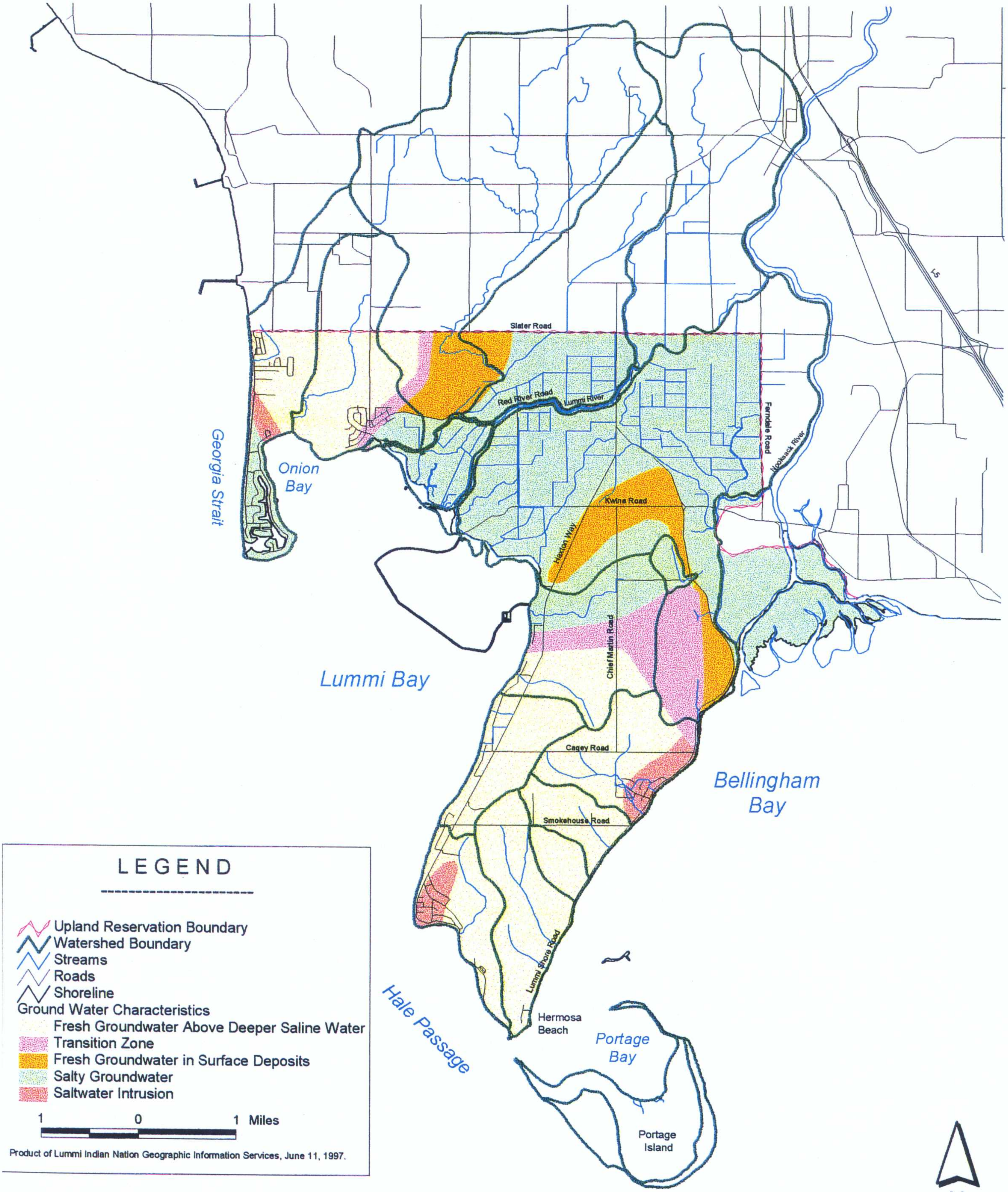

Figure 3.2 - Ground Water Characteristics (Adopted from Cline 1974, Golder 1992.)

Exactly delineating a ground water basin is very difficult in the absence of precise data. However, because a USGS map of the water-table contours and directions of ground water movement on and adjacent to the Reservation suggests that the water table and the ground water flow generally follows the topographic contours of the land surface (Cline 1974), the surface water basins were used to approximate the ground water recharge area. The flow boundaries of Area 2 correspond to the topographic divides delineated from 1:24,000 scale USGS maps (Lummi Bay Quadrangle). It is recognized that the relatively flat topography and the complex geology of variable glacial sediments of different depositional events allows for error in delineating ground water basins based on surface topography.

Area 2 is approximately 6,550 acres in size (10.2 mi^2) and is comprised of three surface water basins. The western surface water basin drains to Georgia Strait and Lummi Bay, the central basin drains to Lummi Bay at Onion Bay, and the eastern basin drains to the Lummi River flood plain. The western and central subbasins contain all public water supply wells and all active individual domestic supply wells in the northern upland part of the Reservation. The potential for developing ground water resources on the Reservation in the eastern subbasin of Area 2 is not known. The wells that have been drilled in this part of the reservation are low in productivity or are nonproductive.

The eastern subbasin of Area 2 corresponds to the watershed of an intermittent stream known as Jordan Creek. While it is unlikely that this entire subbasin serves as a recharge area for the on-Reservation portion of the aquifer, until data are developed that establish the predominant ground water flow directions in this area, the surface water boundaries are used to approximate this portion of the area. This inclusive approach is also intended to protect the on-Reservation aquifer from contaminated surface water originating from the watershed and infiltrating into the aquifer as it flows toward the Lummi River flood plain.

4. INVENTORY OF POTENTIAL CONTAMINANTS

As described previously, the purpose of the susceptibility assessment is to evaluate the vulnerability of wellheads to contamination. A contaminant, as defined in the SDWA, is any physical, chemical, biological, or radiological substance or matter in water. The vulnerability of a wellhead to contaminants is determined by two factors: 1) the physical susceptibility of the wellhead to the infiltration of contaminants, and 2) the risk that the wellhead will be exposed to contaminants.

The physical susceptibility of wellheads to contaminants is determined by factors such as the well depth, well construction, geology of the area, pumping rate, source(s) of recharge, and aquifer material. The risk that the wellhead will be exposed to contaminants is determined largely by the current and historic presence/use of contaminants in the area where water either recharges or is hydraulically connected to the aquifer.

In general, ground water contamination results from (EPA 1993):

- Misuse and improper disposal of liquid and solid wastes.
- Illegal dumping or abandonment of household, commercial, or industrial chemicals.
- Accidental spilling of chemicals from trucks, railways, aircraft, handling facilities, and storage tanks.
- Improper siting, design, construction, operation, or maintenance of agricultural, residential, municipal, commercial, and industrial drinking water wells and liquid and solid waste disposal facilities.
- Atmospheric pollutants.

In this section of the report, a rating system for potential ground water contaminant sources is described, seven categories of potential ground water contaminant sources discussed, and an inventory of potential contaminant sources and potential contaminants associated with each source in the two wellhead protection areas presented. The potential contaminant sources in each of the wellhead protection areas were identified from maps, field visits, aerial photographs, and local knowledge of current and historic land uses. The contaminants associated with each potential source were identified from the literature as typical for the specified land use (EPA 1993) or from 1995 emissions inventory data provided by the Northwest Air Pollution Authority.

4.1 RATING SYSTEM FOR POTENTIAL CONTAMINANT SOURCES

To help prioritize wellhead protection measures (i.e., actions intended to prevent contamination of the Lummi Nation's ground water resources), a ranking system for the potential contaminant sources was developed. The ranking system is based on three factors:

- Location of the potential source relative to ground water supply wells.
- The quantity of potential contaminants either on site or associated with the potential source.

- The hazard posed by the contaminants either to public health or the ground water resource.

The rating system developed for potential contamination sources has three possible ranks: Low (L), Moderate (M), and High (H). A potential source was assigned a "L" rating if only one of the three listed factors is a potential threat to the Reservation aquifers. Similarly, a potential source was assigned a "M" rating if two of the listed factors are present, and a "H" rating if all three of the factors are present. If the quantity of contaminants or the hazardous nature of the contaminants is unknown (e.g., the former landfill along Chief Martin Road), the potential source was assigned a "H" ranking.

Because all of the inventoried potential contaminant sources are located in the newly created wellhead protection areas, all inventoried sources receive at least a "L" ranking. If a potential contaminant source is also associated with large quantities of a potential contaminant(s) or there is a hazard posed by the potential contaminants to either public health or the aquifer, the source was assigned a "M" ranking. If a potential contaminant source is associated with large quantities of a potential contaminant and there is a hazard posed by the potential contaminants to either public health or the aquifer, the source was assigned a "H" ranking. If there are mitigating factors, these factors are identified and the rating for a potential contaminant source was adjusted.

4.2 POTENTIAL GROUND WATER CONTAMINANTS

The potential ground water contaminants were grouped by natural processes and land uses. The seven categories used to group the potential contaminants are (EPA 1987):

- Naturally Occurring Sources
- Agricultural Sources
- Residential Sources
- Municipal Sources
- Commercial Sources
- Industrial Sources
- Industrial Processes

The primary naturally occurring source of ground water contamination in the Lummi wellhead protection areas is salt water originating in Bellingham Bay, Hale Passage, Lummi Bay, and/or Georgia Strait. Although the source of contamination is naturally occurring marine waters, the contamination itself can be and has been the result of human activity. Salt water intrusion into the aquifer from overpumping of near shore wells has been documented at several locations including the Gooseberry Point area near the southwestern end of Area 1 and along the eastern part of Area 1 just north of Cagey Road. The salt water intrusion in the Gooseberry Point area has resulted in the closure of two public water supply wells and limitations on the use of one public water supply well.

In addition to the offshore sources of salty water, naturally occurring saline ground water in the northern portion of Area 1 could potentially contaminate fresh ground water to the south via the transition zone identified by Cline (1974). Golder (1992) identified another transition zone to saline water underlying Area 1 at an approximate elevation of -50 ft msl. Data from a well drilled in 1992 support this hypothesis. Consequently, protection from both vertical and lateral migration of seawater is required.

Other naturally occurring ground water contamination sources include iron and manganese. Both iron and manganese are common in the ground water regionally. It is difficult to predict or delineate the magnitude and distribution of iron and manganese levels due to the complex chemical and physical factors that control the precipitation of iron and manganese oxides in saturated sediments (Golder 1992).

Potential ground water contamination from municipal sources includes the sewer lines of the Lummi Sewer District. Although a sewer system protects ground water quality by replacing septic systems, in all municipal sewer systems the sewer lines are subject to equipment malfunctions that could result in spills or overflows. In addition, spills or leaks could result from damage during construction activities or from damage caused by natural events (e.g., floods, earthquakes). The alarm and emergency response system of the Lummi Sewer District should minimize the impact of any spills in the area serviced by its lines.

Potential ground water contamination from industrial sources includes direct infiltration of contaminants from the Tosco petroleum oil refinery located adjacent to the Reservation boundary. Potential ground water contamination from industrial processes includes the deposition of atmospheric pollutants originating from the area directly north of the Reservation boundary, the Recomp incinerator just east of the Reservation, or from industries along Bellingham Bay. The Cherry Point Heavy Impact Industrial Zone is located to the north, north-northwest, and the northwest of the Lummi wellhead protection areas. This heavy impact industrial zone, the largest such zone in Whatcom County, contains two petroleum oil refineries (Tosco and ARCO) and an aluminum plant (Intalco). One of the oil refineries (Tosco) is located directly north of the Reservation boundary and is partially in Lummi wellhead protection Area 2. Previous owners of this facility were Mobil Oil and British Petroleum. In addition to sources within the Cherry Point Heavy Impact Industrial Zone, ground water contamination is possible through the deposition of atmospheric pollutants originating from the Recomp incinerator along Slater Road, the GN Plywood mill, the Encogen NW Cogeneration Plant, and the Georgia-Pacific West Incorporated paper mill in Bellingham.

A wind rose developed from meteorological data collected at the north boundary of the Tosco oil refinery over the August 1982 through March 1984 period (Mobil Oil Corporation 1986) indicates that the wind direction is from the Cherry Point industries and toward the wellhead protection areas about 6 percent of the time. The wind rose indicates that the wind direction is from the Recomp incinerator to the wellhead protection areas about 40 percent of the time. In contrast, the average annual wind rose for Bellingham indicates that wind direction is generally from the south and southeast (Phillips 1966).

4.3 POTENTIAL CONTAMINANT SOURCES IN AREA 1

An inventory of the potential contaminant sources in Lummi Wellhead Protection Area 1, identification of contaminants generally associated with the potential sources (EPA 1993), the assigned potential aquifer contamination rating, and the justification for the assigned rating is presented in Table 4.1. Each of the potential contaminant sources are grouped by the seven categories of natural processes or land uses presented previously.

As evident by the assigned ratings for the inventoried potential ground water contamination sources in Area 1, the greatest threats to the ground water resources in Area 1 appear to be: salt water intrusion due to overpumping throughout Area 1, confined horses and goats in the Hermosa Beach area, single family residences with private water supply wells and/or septic systems, and an abandoned landfill along Chief Martin Road.

Table 4.1. Inventory of Potential Ground Water Contaminant Sources in Area 1

Potential Contaminant Sources	Potential Contaminants[1]	Location	Potential	Justification
1. Potential Naturally Occurring Sources				
Salt water	Salt water	Bellingham Bay, Hale Passage, Lummi Bay, saline ground water north of Area 1	H	• Location • Quantity • Salt water intrusion due to overpumping has already occurred and resulted in well closures
Iron and manganese	Iron and manganese	Gooseberry Point area	M	• Location • High levels near Gooseberry Point
2. Potential Agricultural Sources				
Approximately 10-acre raspberry farm	Pesticides (e.g., insecticides, herbicides, fungicides), fertilizers, pesticides and fertilizer residue from containers or storage areas; automotive wastes (e.g., gasoline, antifreeze, transmission fluid, battery acid, engine and radiator flushes, engine and metal degreasers, hydraulic fluids, and motor oil)	Smokehouse Road	L	• Location • Small size
Horses and goats	Livestock sewage wastes; nitrates; phosphates; chloride; coliform and noncoliform bacteria; viruses; chemical sprays for controlling insect, bacterial, viral, and fungal pests on livestock	Hermosa Beach Area	H	• Location • Wellhead observed within horse paddock • Total reliance on ground water wells in nearby area
Cattle and sheep	Livestock sewage wastes; nitrates; phosphates; chloride; coliform and noncoliform bacteria; viruses; chemical sprays for controlling insect, bacterial, viral, and fungal	Kwina Road	L	• Location near the northern extent of Area 1 • No active ground water wells nearby

Table 4.1. Inventory of Potential Ground Water Contaminant Sources in Area 1

Potential Contaminant Sources	Potential Contaminants[1]	Location	Potential	Justification
	pests on livestock			
Cattle	Livestock sewage wastes; nitrates; phosphates; chloride; coliform and noncoliform bacteria; viruses; chemical sprays controlling insect, bacterial, viral, and fungal pests on livestock	Portage Island	L	• Location • Maximum of about 40 head of cattle over approximately 1,000 acres; currently being removed from the island.
3. Potential Residential Sources				
Single family homes with private supply wells and/or septic systems	Household cleaners, oven cleaners, drain cleaners, toilet cleaners, disinfectants, metal polishes, jewelry cleaners, shoe polishes, synthetic detergents, bleach, laundry soil and stain removers, spot removers and dry cleaning fluid, solvents, lye or caustic soda, pesticides, photochemicals, printing ink, paints, varnishes, stains, dyes, wood preservatives (cresote), paint and lacquer thinners, paint and varnish removers and deglossers, paint brush cleaners, floor and furniture strippers, automotive wastes, waste oils, diesel fuel, kerosene, #2 heating oil, grease, degreasers for driveways and garages, metal degreasers, asphalt and roofing tar, tar removers, lubricants, rustproofers, car and boat wash detergents, car and boat waxes and polishes, rock salt, refrigerants, fertilizers, herbicides,	Water Supply Wells: Isolated sites concentrated near Hermosa Beach and west of Haxton Way north of Smokehouse Road. Septic Systems: Isolated sites generally toward the interior of Area 1	H	• Location • No 100-feet sanitary control areas visible around many wells • Large number of potential contaminants • Number of failing or improperly working septic systems unknown

Table 4.1. Inventory of Potential Ground Water Contaminant Sources in Area 1

Potential Contaminant Sources	Potential Contaminants[1]	Location	Potential	Justification
	insecticides, fungicides, septage, coliform and noncoliform bacteria, viruses, nitrates, heavy metals, synthetic detergents, cooking and motor oils, bleach, septic tank cleaner chemicals, effluents from barnyards, feedlots, septic tanks, gasoline, water treatment chemicals, and well pumping that induces landward migration of sea water			
Single family homes on municipal water and sewer systems	See listing above	Throughout Area 1	M	• Location • Large number of potential contaminants
4. Potential Municipal Sources				
Roads	Automotive wastes (e.g., gasoline, antifreeze, transmission fluid, battery acid, engine and radiator flushes, engine and metal degreasers, hydraulic fluids, and motor oil)	Throughout Area 1	M	• Location • Large number of potential contaminants
Northwest Indian College	Automotive wastes, general building wastes	Kwina Road	M	• Location • Large number of potential contaminants
Tribal Schools	Automotive wastes, general building wastes	Kwina Road	L	• Location
Lummi Tribal Health Center	Automotive wastes, general building wastes	Kwina Road	M	• Location • Large number of potential contaminants
Tribal governmental offices	Solvents, pesticides, acids, alkalis, waste oils, machinery/vehicle servicing wastes, gasoline or diesel fuel from storage tanks, general building wastes	Kwina Road	M	• Location • Large number of potential contaminants
Biosolids application site	Organic matter, nitrates, inorganic	Haxton Way	M	• Location

Table 4.1. Inventory of Potential Ground Water Contaminant Sources in Area 1

Potential Contaminant Sources	Potential Contaminants[1]	Location	Potential	Justification
	salts, coliform and noncoliform bacteria, parasites, and viruses			• Large number of potential contaminants
Stommish Grounds	Automotive wastes, general building wastes	Lummi View Road	L	• Location
Community Center	Automotive wastes, general building wastes	Lummi View Road	L	• Location
Gooseberry Point Wastewater Treatment Plant	Wastewater, biosolids, treatment chemicals (e.g., chlorine)	Lummi View Road	M	• Location • Large number of potential contaminants
Lummi Cemetery	Leachate, lawn and garden maintenance chemicals	Lummi Shore Road	L	• Location • No wells down gradient
Abandoned landfill	Leachate, organic and inorganic chemical contaminants, wastes from households and businesses, nitrates, oils, metals	Chief Martin Road	H	• Location • Types and quantities of contaminants unknown • Hazardous nature of contaminants unknown
Sewer lines (break or malfunction)	Sewage, coliform and noncoliform bacteria, viruses, nitrates, heavy metals, synthetic detergents, cooking and motor oils, bleach, pesticides, paints, paint thinner, photographic chemicals	Throughout most areas around the perimeter of Area 1 and some interior locations	M	• Location • Moderate quantity of potential contaminants • Potential public health hazard
Public water supply wells	Water treatment chemicals and well pumping that induces landward and/or vertical migration of sea water	Throughout Area 1 but concentrated along shoreline areas	M	• Location • Chloride, pumping rates, and water level monitored monthly • Large quantity of potential contaminants • Water quality monitored regularly in accordance with Safe Drinking Water Act
5. Potential Commercial Sources				
Ray Beck Construction	Oils, waste oils, solvents, grease, hydraulic fluids, transmission fluids, antifreeze, acids, paints, miscellaneous cutting oils, and miscellaneous wastes	Kwina Road	M	• Location • Large number of potential contaminants

Table 4.1. Inventory of Potential Ground Water Contaminant Sources in Area 1

Potential Contaminant Sources	Potential Contaminants[1]	Location	Potential	Justification
Weld Shop	Oxygen, acetylene	Haxton Way	L	• Location
Lummi Auto Recyclers	Waste oils, solvents, acids, paints, and automobile wastes	Cagey Road	M	• Location • Large number of potential contaminants
Eagle Haven recreational vehicle (RV) park	Septage, gasoline, diesel fuel pesticides, automotive wastes, and household wastes	Smokehouse Road	M	• Location • Large number of potential contaminants
Fisherman's Cove (boat storage, launching, and repair)	Diesel fuel, oil, septage from boat waste disposal areas, wood preservative and treatment chemicals, paints, waxes, varnishes, automotive wastes	Gooseberry Point	M	• Location • Large number of potential contaminants
Fisherman's Cove Marina (retail grocer)	Automotive wastes, general building wastes	Gooseberry Point	L	• Location
Lummi Casino	Automotive wastes, general building wastes	Gooseberry Point	L	• Location
The Lummi Tribal Enterprises seafood processing plant	Automotive wastes, general building wastes	Gooseberry Point	L	• Location
Finkbonner Shellfish Inc.	Automotive wastes, general building wastes	Lummi View Road	L	• Location
Native American Shellfish Inc.	Automotive wastes, general building wastes	Lummi Shore Road	L	• Location
Utilities	PCBs from transformers and capacitors, oils, solvents, sludges, acid solution, metal plating solutions (chromium, nickel, cadmium)	Throughout Area 1	M	• Location • Large number of potential contaminants
6. Potential Industrial Sources				
No industrial sources of ground water contamination	N/A	N/A	N/A	N/A
7. Potential Sources of Industrial Processes (atmospheric deposition)				
Tosco Refining and Marketing (petroleum oil refinery)	<u>Criteria Pollutants:</u> Volatile Organic Compounds (VOCs), fine particulate matter, oxides of	Unick Road (north of Reservation)	M	• Large number of potential contaminants • Potential hazard of contaminants

Table 4.1. Inventory of Potential Ground Water Contaminant Sources in Area 1

Potential Contaminant Sources	Potential Contaminants[1]	Location	Potential	Justification
	nitrogen, carbon monoxide, oxides of sulfur Toxic Pollutants: benzene, butanes, cyclohexane, ethylbenzene, pentanes, toluene, trimethylbenzene, xylene, and other toxins in quantities less than 5,000 lbs per year			
Intalco Aluminum Corporation (aluminum plant)	Criteria Pollutants: VOCs, fine particulate matter, oxides of nitrogen, carbon monoxide, oxides of sulfur Toxic Pollutants: gaseous flouride	Mt. View Road (north of Reservation)	M	• Large number of potential contaminants • Potential hazard of contaminants
ARCO Product Company (petroleum oil refinery)	Criteria Pollutants: VOCs, fine particulate matter, oxides of nitrogen, carbon monoxide, oxides of sulfur Toxic Pollutants: benzene, cyclohexane, ethylbenzene, sulfuric acid, toluene, trimethylbenzene, xylene, and other toxins in quantities less than 5,000 lbs per year	Grandview Road (north of Reservation)	M	• Large number of potential contaminants • Potential hazard of contaminants
RECOMP of Washington Inc. (waste disposal, incinerator)	Criteria Pollutants: Fine particulate matter, oxides of nitrogen, carbon monoxide, oxides of sulfur Toxic Pollutants: aluminum, barium, cadmium, chlorobenzene, cobalt, copper, flourene, hydrogen chloride, lead, manganese, mercury, and silver	Slater Road (east of Reservation	M	• Large number of potential contaminants • Potential hazard of contaminants
GN Plywood, Inc.	Criteria Pollutants: VOCs, fine	Bellingham	M	• Large number of potential contaminants

Table 4.1. Inventory of Potential Ground Water Contaminant Sources in Area 1

Potential Contaminant Sources	Potential Contaminants[1]	Location	Potential	Justification
(plywood manufacturer)	particulate matter, oxides of nitrogen, carbon monoxide Toxic Pollutants: acetaldehyde, acetone, barium, benzene, chlorine, formaldehyde, manganese, naphthalene	(east of Reservation)		• Potential hazard of contaminants
Encogen NW Cogeneration Plant	Criteria Pollutants: VOCs, fine particulate matter, oxides of nitrogen, carbon monoxide, oxides of sulfur Toxic Pollutants: ammonia, formaldehyde	Bellingham (east of Reservation)	M	• Large number of potential contaminants • Potential hazard of contaminants
Georgia-Pacific West, Inc (paper pulp mill)	Criteria Pollutants: VOCs, fine particulate matter, oxides of nitrogen, carbon monoxide, oxides of sulfur Toxic Pollutants: acetaldehyde, acetone, barium, chlorine, chloroform, dichlorodifluoromethane, ethanol, formaldehyde, hydrochloric acid, methylethyl ketone, methanol, sulfuric acid, and other toxins in quantities less than 5,000 lbs/year	Bellingham (east of Reservation)	M	• Large number of potential contaminants • Potential hazard of contaminants

[1] Potential contaminant listings based on literature (EPA 1993) and 1995 emission inventory information provided by the Northwest Air Pollution Authority. Other than emission inventories, site specific inventories of potential contaminants at each location were not conducted.

4.4 POTENTIAL CONTAMINANTS IN AREA 2

An inventory of the potential contaminant sources in Lummi Wellhead Protection Area 2, identification of contaminants generally associated with the potential sources (EPA 1993), the assigned potential aquifer contamination rating, and the justification for the assigned rating is presented in Table 4.2.

As evident by the assigned ratings for the inventoried potential sources in Area 2, the greatest threats to the ground water resources in Area 2 appear to be: salt water intrusion due to overpumping along the western part of Area 2, single family residences with private supply wells and/or septic systems, roads, manure lagoons, and the Tosco refinery. The roads in Area 2 are assigned a higher potential aquifer contamination rating than the roads in Area 1 because of the industrial traffic that occurs along the road ways in Area 2 and because herbicides are used along some of the road right-of-ways.

Table 4.2. Inventory of Potential Ground Water Contaminant Sources in Area 2

Potential Contaminant Sources	Potential Contaminants[1]	Location	Potential	Justification
1. Potential Naturally Occurring Sources				
Salt water	Salt water	Georgia Strait, Lummi Bay	H	• Location • Quantity • Salt water intrusion due to overpumping has already occurred in several nearshore wells
2. Potential Agricultural Sources				
Sheep, cattle, horses, and llamas	Livestock sewage wastes; nitrates; phosphates; chloride; coliform and noncoliform bacteria; viruses; chemical sprays for controlling insect, bacterial, viral, and fungal pests on livestock	Neptune Beach Area and north of Reservation	M	• Location • Active water supply wells nearby • Small area
Cattle	Livestock sewage wastes; nitrates; phosphates; chloride; coliform and noncoliform bacteria; viruses; chemical sprays for controlling insect, bacterial, viral, and fungal pests on livestock	Sucia Drive and north of Reservation	M	• Location • Active water supply wells nearby
Sewage disposal ponds (manure lagoons)	Organic matter, nitrates, inorganic salts, coliform and noncoliform bacteria, parasites, and viruses	North of Reservation	H	• Location • Large number of potential contaminants • Potential hazard of contaminants
Agricultural drainage canals	Pesticides, fertilizers, bacteria, livestock sewage, nitrates	North of Reservation	M	• Location • Large number of potential contaminants
3. Potential Residential Sources				
Single family homes with private supply wells and/or septic systems	Household cleaners, oven cleaners, drain cleaners, toilet cleaners, disinfectants, metal	Water Supply Wells: Isolated sites	H	• Location • No 100-feet sanitary control areas visible around many wells

Table 4.2. Inventory of Potential Ground Water Contaminant Sources in Area 2

Potential Contaminant Sources	Potential Contaminants[1]	Location	Potential	Justification
	polishes, jewelry cleaners, shoe polishes, synthetic detergents, bleach, laundry soil and stain removers, spot removers and dry cleaning fluid, solvents, lye or caustic soda, pesticides, photochemicals, printing ink, paints, varnishes, stains, dyes, wood preservatives (cresote), paint and lacquer thinners, paint and varnish removers and deglossers, paint brush cleaners, floor and furniture strippers, automotive wastes, waste oils, diesel fuel, kerosene, #2 heating oil, grease, degreasers for driveways and garages, metal degreasers, asphalt and roofing tar, tar removers, lubricants, rustproofers, car and boat wash detergents, car and boat waxes and polishes, rock salt, refrigerants, fertilizers, herbicides, insecticides, fungicides, septage, coliform and noncoliform bacteria, viruses, nitrates, heavy metals, synthetic detergents, cooking and motor oils, bleach, septic tank cleaner chemicals, effluents from barnyards, feedlots, septic tanks, gasoline, water treatment chemicals, and well pumping that induces landward migration of	concentrated along Sucia Drive and north of Reservation Septic Systems: Neptune Circle, southern extent of Salt Spring Drive, parts of Sandy Point Heights, isolated sites generally toward the interior of Area 2 and north of the Reservation		• Large number of potential contaminants • Number of failing or improperly working septic systems unknown

Table 4.2. Inventory of Potential Ground Water Contaminant Sources in Area 2

Potential Contaminant Sources	Potential Contaminants[1]	Location	Potential	Justification
	sea water			
Single family homes on municipal water and sewer systems	See listing above	Throughout Area 2	M	• Location • Large number of potential contaminants
4. Potential Municipal Sources				
Roads	Automotive wastes (e.g., gasoline, antifreeze, transmission fluid, battery acid, engine and radiator flushes, engine and metal degreasers, hydraulic fluids, and motor oil), herbicides along road right-of-ways	Throughout Area 2	H	• Location • Large number of potential contaminants • Potential hazard of contaminants
Sandy Point Wastewater Treatment Plant	Wastewater, biosolids, treatment chemicals (e.g., chlorine)	Germaine Road	M	• Location • Large number of potential contaminants
Sewer lines	Sewage, coliform and noncoliform bacteria, viruses, nitrates, heavy metals, synthetic detergents, cooking and motor oils, bleach, pesticides, paints, paint thinner, photographic chemicals	Throughout many areas of Reservation in Area 2	M	• Location • Moderate quantity of potential contaminants • Potential public health hazard
Public water supply wells	Water treatment chemicals and well pumping that induces landward and vertical migration of sea water	Concentrated in the residential areas along the southwestern parts of Area 2	M	• Location • Chloride, pumping rates, and water level monitored in some wells • Large quantity of potential contaminants • Water quality monitored regularly in accordance with Safe Drinking Water Act • No alternative source currently available
5. Potential Commercial Sources				
Warrior Construction	Oils, waste oils, solvents, grease, hydraulic fluids, transmission fluids, antifreeze, acids, paints, miscellaneous cutting oils, and	North Red River Road	M	• Location • Large number of potential contaminants

Table 4.2. Inventory of Potential Ground Water Contaminant Sources in Area 2

Potential Contaminant Sources	Potential Contaminants[1]	Location	Potential	Justification
	miscellaneous wastes			
Arnold Finkbonner and Sons (sand and gravel hauling company)	Oils, waste oils, solvents, grease, hydraulic fluids, transmission fluids, antifreeze, acids, paints, miscellaneous cutting oils, and miscellaneous wastes	Germaine Road	M	• Location • Large number of potential contaminants
Barlean's Fishery	Automotive wastes, general building wastes	Lake Terrell Road (north of Reservation)	M	• Location • Uncertain sources from variety of commercial activities
Woodland Nursery	Pesticides (e.g., insecticides, herbicides, fungicides), fertilizers, pesticides and fertilizer residue from containers or storage areas; automotive wastes (e.g., gasoline, antifreeze, transmission fluid, battery acid, engine and radiator flushes, engine and metal degreasers, hydraulic fluids, and motor oil)	Elder Road (north of Reservation)	L	• Location • Small size
Utilities	PCBs from transformers and capacitors, oils, solvents, sludges, acid solution, metal plating solutions (chromium, nickel, cadmium)	Throughout Area 2	M	• Location • Large number of potential contaminants
6. Potential Industrial Sources				
Tosco Refining and Marketing (petroleum oil refinery)	Hydrocarbons, solvents, metals, miscellaneous organics, sludges, oily metal shavings, lubricant and cutting oils, degreasers, metal marking fluids, corrosive fluids, other hazardous and nonhazardous materials and	Unick Road (north of Reservation)	H	• Location • Large number of potential contaminants • Potential hazard of contaminants

Table 4.2. Inventory of Potential Ground Water Contaminant Sources in Area 2

Potential Contaminant Sources	Potential Contaminants[1]	Location	Potential	Justification
	wastes, diesel fuel, herbicides for rights-of-way, creosote for preserving railroad ties			
7. Potential Sources of Industrial Processes (atmospheric deposition)				
Tosco Refining and Marketing (petroleum oil refinery)	Criteria Pollutants: Volatile Organic Compounds (VOCs), fine particulate matter, oxides of nitrogen, carbon monoxide, oxides of sulfur Toxic Pollutants: benzene, butanes, cyclohexane, ethylbenzene, pentanes, toluene, trimethylbenzene, xylene, and other toxins in quantities less than 5,000 lbs per year	Unick Road (north of Reservation)	M	• Large number of potential contaminants • Potential hazard of contaminants
Intalco Aluminum Corporation (aluminum plant)	Criteria Pollutants: VOCs, fine particulate matter, oxides of nitrogen, carbon monoxide, oxides of sulfur Toxic Pollutants: gaseous flouride	Mt. View Road (north of Reservation)	M	• Large number of potential contaminants • Potential hazard of contaminants
ARCO Product Company (petroleum oil refinery)	Criteria Pollutants: VOCs, fine particulate matter, oxides of nitrogen, carbon monoxide, oxides of sulfur Toxic Pollutants: benzene, cyclohexane, ethylbenzene, sulfuric acid, toluene, trimethylbenzene, xylene, and other toxins in quantities less than 5,000 lbs per year	Grandview Road (north of Reservation)	M	• Large number of potential contaminants • Potential hazard of contaminants
RECOMP of Washington Inc. (waste disposal, incinerator)	Criteria Pollutants: Fine particulate matter, oxides of	Slater Road (east of	M	• Large number of potential contaminants

Table 4.2. Inventory of Potential Ground Water Contaminant Sources in Area 2

Potential Contaminant Sources	Potential Contaminants[1]	Location	Potential	Justification
	nitrogen, carbon monoxide, oxides of sulfur Toxic Pollutants: aluminum, barium, cadmium, chlorobenzene, cobalt, copper, flourene, hydrogen chloride, lead, manganese, mercury, and silver	Reservation		• Potential hazard of contaminants
GN Plywood, Inc. (plywood manufacturer)	Criteria Pollutants: VOCs, fine particulate matter, oxides of nitrogen, carbon monoxide Toxic Pollutants: acetaldehyde, acetone, barium, benzene, chlorine, formaldehyde, manganese, naphthalene	Bellingham (east of Reservation)	M	• Large number of potential contaminants • Potential hazard of contaminants
Encogen NW Cogeneration Plant	Criteria Pollutants: VOCs, fine particulate matter, oxides of nitrogen, carbon monoxide, oxides of sulfur Toxic Pollutants: ammonia, formaldehyde	Bellingham (east of Reservation)	M	• Large number of potential contaminants • Potential hazard of contaminants
Georgia-Pacific West, Inc. (paper pulp mill)	Criteria Pollutants: VOCs, fine particulate matter, oxides of nitrogen, carbon monoxide, oxides of sulfur Toxic Pollutants: acetaldehyde, acetone, barium, chlorine, chloroform, dichlorodifluoromethane, ethanol, formaldehyde, hydrochloric acid, methylethyl ketone, methanol, sulfuric acid, and other toxins in	Bellingham (east of Reservation)	M	• Large number of potential contaminants • Potential hazard of contaminants

Table 4.2. Inventory of Potential Ground Water Contaminant Sources in Area 2

Potential Contaminant Sources	Potential Contaminants[1]	Location	Potential	Justification
	quantities less than 5,000 lbs/year			

[1] Potential contaminant listings based on literature (EPA 1993) and emission inventory information provided by the Northwest Air Pollution Authority. Other than emission inventories, site specific inventories of potential contaminants at each location were not conducted.

5. WATER SUPPLY REPLACEMENT OPTIONS

As described in the introduction section, the purpose of a contingency plan is to prepare for an emergency that would cause the current and/or future ground water supply of the Reservation to become unusable. Such an emergency could develop over several years (e.g., more extensive salt water intrusion due to overpumping, atmospheric deposition of toxic compounds) or could develop suddenly (e.g., a spill of toxic material in the wellhead protection area). While many of the contaminants identified in the susceptibility assessment have the potential to cause the closure of limited portions of the aquifer, it is unlikely that the entire ground water resource would become unusable. The Lummi Nation's ground water monitoring program established in 1991 should help identify early signs of salt water intrusion and allow for corrective actions to minimize the extent of contamination should it occur.

The contingency plan is an analysis of water supply replacement options and associated costs. The plan examines replacement options for both current and future water supply needs on the Reservation. In addition to providing information for emergency preparedness, a simplified analysis of the estimated costs to replace the existing and future water supply will help define the economic context of any proposed wellhead protection measures.

5.1 CURRENT RESERVATION WATER SUPPLY

Water supply replacement options on the Reservation are affected by the existing water systems, alternative water supply sources, and the estimated replacement costs.

5.1.1 Existing Water Systems

Currently, there are four types of water purveyors on the Reservation. Three of these purveyorships supply potable water and one provides untreated ground water primarily for salmon egg incubation and a limited salmon rearing operation. The four types of purveyors are listed below and their general service areas shown in Figure 5.1. Areas in Figure 5.1 that are not adjacent to the Lummi water lines or not within a water association are either undeveloped or obtain water from individual or private wells.

1. The Lummi Water District is the largest and the most geographically comprehensive water system on the Reservation. The Lummi Water District operates a network of six production wells and approximately 472,000 gallons of reservoir storage (in three storage tanks ranging in capacity from 97,000 to 250,000 gallons). The Lummi Water District can also purchase and import potable water from the City of Bellingham via a 10-inch ductile iron pipeline. In 1996, the Lummi Water District provided water to about 485 residential connections (about 27.6 percent of the approximately 1,760 residential units on the Reservation) as well as to municipal and commercial operations.

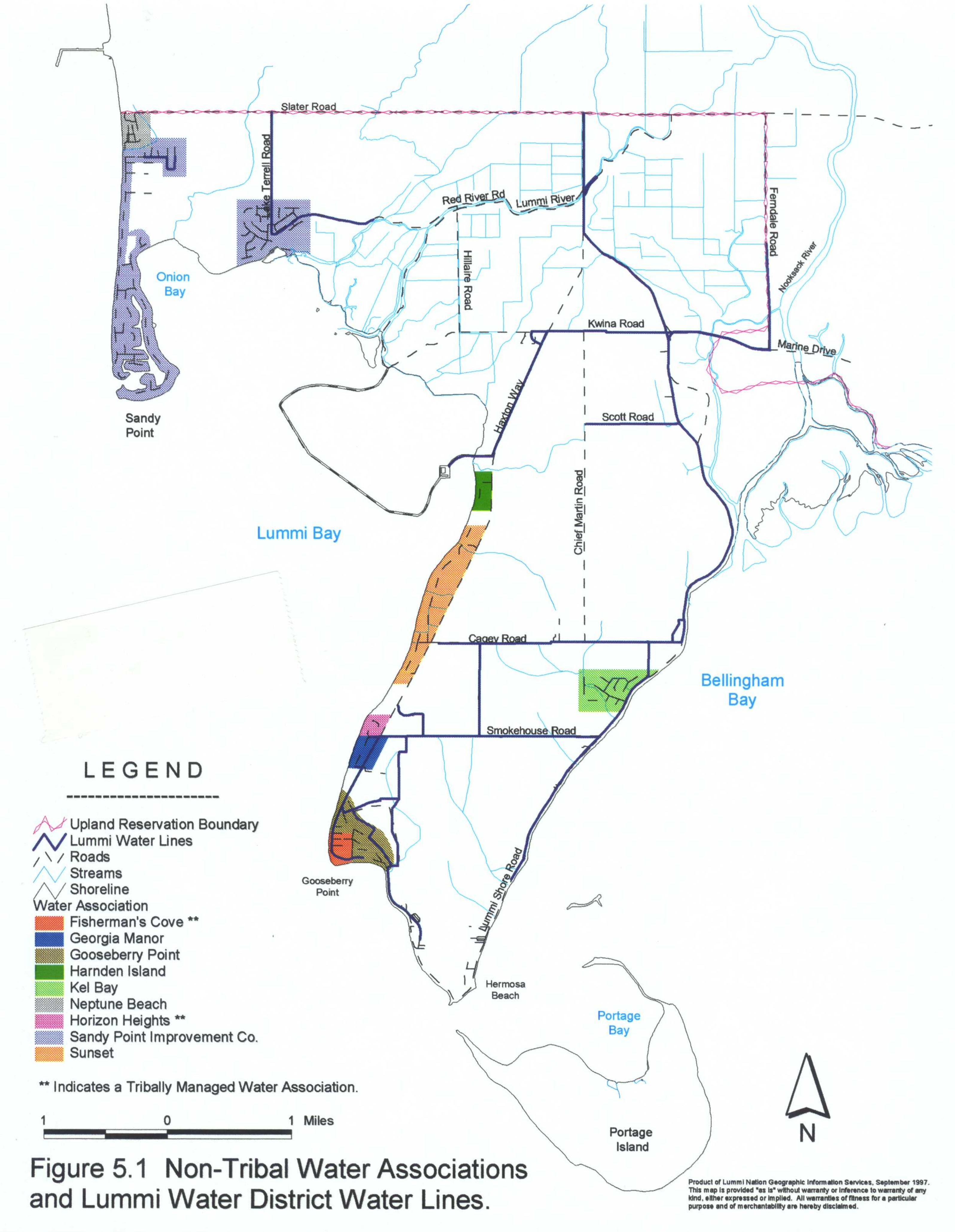

Figure 5.1 Non-Tribal Water Associations and Lummi Water District Water Lines.

2. Nine small water systems operated by non-tribal water associations currently serve predominantly non-tribal members in dense residential areas located along the Reservation shorelines. The nine non-tribal water associations are: Neptune Beach, Sandy Point Improvement Company, Sunset, Georgia Manor, Harnden Island View, Leeward-Northgate, Gooseberry Point, Gulfside Mobile Home Park, and Kel Bay. These nine water associations, whose legal status is in question in light of a 1982 Consent Decree recognizing the Lummi Nation as the sole purveyor of water service on the Reservation, rely exclusively on ground water wells for supply. In February 1997, the Lummi Water Resources Division estimated that these nine water associations provide water to about 1150 connections or about 65.3 percent of the residential units on the Reservation.

3. Individual or private wells that supply water to one or more Reservation residents. The Lummi Water Resources Division estimates that in 1996 there were approximately 125 residential units on the Reservation (7.1 percent of total) supplied by individual or small group domestic water supply wells. About 75 percent of these residential units are non-tribally owned.

4. The Lummi Natural Resources Department operates a well along Neptune Circle that currently provides untreated water to the Sandy Point salmon propagation facility, a sand and gravel transport company, and two tribal homes near Germaine Road.

5.1.2 Alternative Water Supply

Local ground water is the only water source available to Reservation residents who are not supplied by the Lummi Water District. Although the Lummi Water District has access to an alternative water supply source, the high cost of the imported water and concerns about the impact of the City of Bellingham's diversion on Nooksack River fisheries resources limit the utilization of the Bellingham supply. Currently the Bellingham line is used only as a stand-by source for the Lummi Water District. In 1996, about 10 percent of the water supplied by the Lummi Water District came from the Bellingham water line. The current design capacity and contractual limits of this water line are approximately 1,000 gallons per minute (gpm) or about 1.4 million gallons per day (gpd).

As stated previously, the nine non-tribal water associations on the Reservation use ground water and have no alternative supply. In 1990, the Lummi Nation offered to consolidate the non-tribal systems with the tribal system, to upgrade and manage the systems for aquifer protection, and to meet existing and future legal obligations for service. One of the water associations (Horizon Heights) accepted the offer and the system was upgraded and integrated into the Lummi Water District's system. A second former water association purchased by the Lummi Nation in the late 1980s (Fisherman's Cove) was upgraded and integrated into the Lummi Water District's system at about the same time. In 1991 the Lummi Water District shut down the former Fisherman's Cove Water Association well and another nearby tribal public supply well due to salt water intrusion. The remaining nine non-tribal water associations refused the tribe's offer to become integrated into the Lummi Water District's system and are entirely dependent on wells adjacent to or within the association boundaries.

If it is assumed that the average annual water use per residential unit on the Reservation is 250 gpd, approximately 440,000 gpd are required to meet the current residential demand of the approximately 1,760 units on the Reservation (tribal and non-tribal). In addition to these residential water demands, the water use by the existing commercial and the salmon propagation program averages about 143,000 gpd. The current total average annual water demand for the Reservation is thus approximately 583,000 gpd or about 212,795,000 gallons per year (653 acre-feet). To supply the average daily water demand of 583,000 gallons, the wells on the Reservation would need to be pumped at a combined continuous average rate of about 405 gallons per minute (gpm).

If a portion of the Reservation aquifers were contaminated and no longer useable, the existing Bellingham water supply line could be used to meet the current potable water demands. Although the water line from the City of Bellingham could support the potable water supply demands, the chlorinated water could not be used to replace the ground water for the salmon propagation program. The water supply to the salmon hatchery is non-chlorinated and cannot be mixed with chlorinated water since chlorine is toxic to salmon at very low concentrations.

Even though the Bellingham water line could replace unusable ground water as a potable water supply, only Lummi Water District customers have access to the alternative source. The nine water associations and the Reservation residents supplied by individual domestic supply wells are not connected to the Lummi Water District's distribution network. In the event that a portion of the aquifer became unusable, these entities would have to develop an additional alternative source or become Lummi Water District customers under an arrangement with the Lummi Nation. In most cases, the existing water distribution system would have to be enlarged to serve these areas.

5.1.3 Estimated Replacement Costs

An extension or expansion of the Lummi Water District's distribution system would be costly. Although the total infrastructure needs and associated costs would have to be evaluated as part of an overall water system integration plan, pipelines alone would cost about $22.00 per lineal foot. Engineering design costs, additional reservoir storage capacity, additional pumping costs, valves, meters, fire hydrants, and other infrastructure would all have to be paid for as part of a system expansion. Additional water district staff would also be required.

For the purposes of this contingency plan, a general, simplified analysis was used to evaluate the monetary costs associated with a replacement water supply. A true economic analysis of replacement costs would require the services of a professional economist and is beyond the scope of the present effort. In this simplified analysis, it is assumed that any infrastructure needed to integrate the Lummi Water District and non-tribal water associations and/or tribal and non-tribal homes using private wells will be paid for by the water association members and individuals who will directly benefit from the integration. Consequently, the cost of an alternative water supply for the Lummi Water District was computed simply as the cost of replacing one water source (local ground water wells) with another (purchased water from the City of Bellingham). That is:

Cost of Alternative Source = Cost of Bellingham Water - Well Operation Costs

Despite its limitations, the simplified equation is useful to help evaluate the monetary value of ground water protection. The simplified equation allows for an approximation of the monetary costs associated with incremental increases in reliance on water purchased from the City of Bellingham. Incremental increases in reliance on the alternative source could occur if pumping rates were reduced to preclude salt water intrusion or if entire wells were shut down due to contamination from one of the potential sources. In Table 5.1, the lost ground water supply is expressed as a “well equivalent”, as an average pumping rate, and as a lost volume. Based on the pumping rates of Lummi Water District wells, one well equivalent was assigned an average pumping rate of 20 gpm.

The current monthly cost to the Lummi Water District for purchasing water from the City of Bellingham is \$23.25 for the first 1,200 ft^3 (8,976 gallons) and \$1.245 for every 100 ft^3 (748 gallons) thereafter. The average annual cost to operate and maintain the pumps at the six water supply wells (electric power, chlorine, miscellaneous repairs) is estimated to be around \$25,000. This annual cost of about \$4,200 per well averages to about \$350 per month per well for operation and maintenance costs. These operation and maintenance costs would not be necessary if a well were shut down and the water supply replaced with water purchased from the City of Bellingham. It is assumed that routine water quality monitoring, pipeline maintenance, and the associated costs would continue even if an additional supply is purchased from Bellingham.

As shown in Table 5.1, one 20 gpm well produces an average of 115,504 cubic feet (ft^3) per month. At an operation cost of \$350 per month, the cost of obtaining this amount of water from a local ground water well is about 0.3 cents per cubic foot. Obtaining this quantity of water from the City of Bellingham would cost about \$1,446 per month or about 1.25 cents per cubic foot. In essence, obtaining water from Bellingham costs a little over four times what it costs to obtain water from local ground water wells.

At current prices, the water from the City of Bellingham costs approximately 0.95 cents more than the water obtained from local ground water wells. The monthly replacement cost of about \$1,096 suggests that the Lummi Water District’s rates would have to be raised an average of \$2.26 for the current 485 residential customers if the production equivalent to one 20 gpm well was lost. This increase represents about an 11 percent increase over the current average monthly Lummi Water District residential customer bill of \$21.00.

Table 5.1 Estimated current monthly incremental water supply replacement costs

Lost Well Equivalent (1 well = 20 gpm)	Lost Average Pumping Rate (gpm)	Lost Average Monthly Volume (ft^3)	Average Monthly Replacement Cost		
			Bellingham Water ($)	Reduced Well Operation Cost ($)	Total Estimated Monthly Replacement Cost ($)
0.5	10	57,754	727.35	175.00	552.35
1	20	115,504	1,446.33	350.00	1,096.33
1.5	30	173,262	2,165.42	525.00	1,640.42
2	40	231,016	2,884.46	700.00	2,184.46
2.5	50	288,770	3,603.50	875.00	2,728.50
5	100	577,540	7,198.68	1,750.00	5,448.68

It is noted that the monetary value of an alternative water supply computed by the simplified equation does not address the impacts to the Nooksack River fisheries resources that could result from any increased diversions necessary to supply the water. The simplified equation used to estimate the water replacement cost also does not address the cost to the Lummi Nation of depleting a ground water resource in a region with a limited water supply. It is impossible to put a true value on a resource that is essential to life, is finite, and is irreplaceable. For the Lummi Nation, ground water is also culturally significant as a component of the natural environment. A variety of experts, in consultation with the Lummi Nation, would be needed to assess and develop an estimate of the cost of replacement and/or restoration of the Nation's trust resources.

5.2 FUTURE RESERVATION WATER SUPPLY

The Lummi Planning Department used demographic profile data from the 1990 Census and projected that between 3,810 and 4,350 housing units will be needed on the Reservation by the year 2010 (LIBC 1996). These population projections, planned economic and institutional growth on the Reservation, the fact that there are currently nearly 900 tribal members on a waiting list for individual homes on the Reservation, and the small percentage of tribal land that has been developed all suggest that eventually the available ground water supply on the Reservation will not be adequate for the residential water supply needs of the Lummi Nation.

Assuming that these projections for 2010 are accurate, that the needed 3,810 to 4,350 units are constructed, and the estimated current average annual water use per residential unit is representative of future use, in the year 2010 between 950,000 and 1,087,500 gallons per day (gpd) of potable water will be needed to supply the residential Reservation water needs alone. According to this formula, the residential demand in the year 2010 for 1,087,500 gpd is about 396,937,500 gallons per year (1,218 acre-feet) or about double the current demand for water.

In addition to the future residential water demand, it is likely that new commercial enterprises will be established on the Reservation in the coming years to meet the economic development needs of the current and future population. Existing institutional water needs will also increase in the coming years. For example, the Northwest Indian

College is expanding with the planned addition of student housing in 1998 and the planned expansion of the curriculum to offer a four-year degree in the coming years. Whether for domestic, commercial, municipal, industrial, or hatchery uses, future water needs on the Reservation will increase and be substantial.

Although the total future water needs of projected residential, commercial, and institutional expansion on the Reservation are unknown, it is reasonable to expect the water needs of the Lummi Nation to triple over the next 10 to 20 years. In light of the fact that the local geology limits ground water recharge, the areal extent of fresh ground water resources on the Reservation is limited, and salt water intrusion has already resulted in the closure of several water supply wells, it is clear that the available ground water supply on the Reservation will not be adequate for the future needs of the Lummi Nation.

Although it is an unlikely scenario, if both of the aquifer systems became completely unusable and the current water demands were doubled, the existing Bellingham water supply line and contract limit of 1.4 million gpd could provide enough water to meet the potable water demands of the Reservation. However, neither the physical capacity of the line nor the contractual arrangement with the City of Bellingham would be adequate if the Lummi Nation's aquifers became completely unusable and water demand on the Reservation was tripled. There are no assurances that the City of Bellingham would sell more water to the Lummi Nation or that funding would be available for the substantial upgrades required to increase the physical capacity of the pipeline. The cost to replace the water supply would be much greater if the salmon hatchery supply well became unusable and it became necessary to identify and develop an alternative source of non-chlorinated water.

The importance of wellhead protection is underscored by the fact that the existing alternative water source cannot supply the projected future demand of the Lummi Nation. Although the future cost to develop a new water source is unknown, an estimated financial cost to replace the future Reservation ground water supply could not address the cost to the Lummi Nation of depleting a ground water resource in a region with a limited water supply. As stated previously, it is impossible to put a true value on a resource that is essential to life, is finite, and is irreplaceable. The ground water resources are also culturally important to the Lummi Nation as a component of the natural environment.

6. COMMUNITY INVOLVEMENT PLAN

Community involvement is a critical element of a wellhead protection program. As stated previously, the Lummi Natural Resources Department decided that the largely technical elements of the wellhead protection program would be completed prior to implementing a community involvement plan. The two elements of the community involvement plan are 1) public education and, 2) interjurisdictional coordination and cooperation.

Community involvement in a wellhead protection program is necessary for a number of reasons including:

- Ground water movement does not follow private property or political boundaries.
- Community participation in developing and implementing the management plan is critical to program success.

The public education element of the Lummi Wellhead Protection Program will include articles in the Lummi Nation newspaper *Squol Quol* and a slide presentation about the Lummi Wellhead Protection Program. The draft text of the planned first article for the *Squol Quol* is shown in Appendix B. A slide presentation will be provided to interested groups including the following LIBC commissions, boards, and staff: Natural Resources Commission, Planning Commission, Economic Development Commission, Water Board, Housing Board, Lummi Water District staff, and the Lummi Indian Business Council (LIBC). The presentation will also be provided to audiences such as the Lummi Tribal Health Center, Lummi Tribal School, Lummi High School, the Northwest Indian College, and to any other group that requests a presentation. Because the pollution prevention goals of the wellhead protection program are similar to some of the storm water management program goals, it is likely that some elements of the public education campaign for the two programs will complement each other.

The interjurisdictional coordination and cooperation element of the plan will start within the LIBC. The Lummi Natural Resources Department will work closely with the Lummi Water District, the Lummi Planning Department, the Lummi Tribal Health Center, and other LIBC agencies to implement the public education element of the plan, develop spill prevention plans, and develop wellhead protection measures.

Externally, the Lummi Natural Resources Department needs to meet with the environmental officers at the Tosco refinery to describe the Lummi Wellhead Protection Program; identify its concerns about having a heavy impact industry adjacent to the Reservation; request to review their pollution prevention plan, spill prevention and control plan, emissions control plan, storm water quality monitoring plan, and other plans developed to reduce environmental impacts of their operations. Any available reports that evaluate the implementation of the plans should also be requested.

It is anticipated that similar meetings will be held with parties such as the Whatcom County Planning and Development Department, which regulates land use in the off-Reservation portions of the northern upland.

In addition to the public involvement in Phase II of the Lummi Nation Wellhead Protection Program development, public hearings will be held in accordance with LIBC policies and procedures if a wellhead protection ordinance is identified in Phase II as one of the protective measures.

7. CONCLUSION

The largely technical components of the Lummi Wellhead Protection Program plan (Phase I) have been completed. The completed susceptibility assessment and contingency plan components will serve as the basis for the community involvement, spill response planning, and development and implementation of wellhead protection measures in the coming months (Phase II and Phase III).

Two wellhead protection areas were delineated based on the flow boundaries approach and available hydrogeologic mapping. Wellhead protection Area 1 is the southern upland area of the Reservation and includes most of the Lummi Peninsula and Portage Island. Area 2 is the northern upland area and extends north of the Reservation boundary.

As part of the susceptibility assessment, potential sources of aquifer contaminants from agricultural, residential, municipal, commercial, and industrial land uses in each of the wellhead protection areas were inventoried. Available literature and emissions inventories were used to identify potential aquifer contaminants associated with each source. Based on the location of each potential contaminant source, the quantity of potential contaminants associated with the source, and the hazard represented by the contaminants, each potential source was assigned a potential hazard rating of low, moderate, or high.

Salt water intrusion caused by overpumping is a major threat to the Lummi Nation's ground water resources in both Area 1 and Area 2. The Reservation is located in a coastal area and most of the existing water supply wells on the Reservation are within a half mile of marine waters. Progressive salt water intrusion induced by overpumping of nearshore wells has already led to the closure of several wells on the Reservation. Other major threats to the ground water supply in Area 1 include: horses and goats fenced within residential areas near Hermosa Beach, single family residential units relying on private water supply wells and/or septic systems, and an abandoned landfill along Chief Martin Road. In Area 2, the major threats to the ground water supply (after salt water intrusion) include: single family residential units relying on private water supply wells and/or septic systems, roadways (i.e., transportation corridors for the Cherry Point Heavy Impact Industrial Zone), manure lagoons north of the Reservation, and the Tosco petroleum oil refinery.

Using current water price information and a simplified equation, it was determined that obtaining water from Bellingham costs about four times more than obtaining water from local ground water wells. At current prices, every 20 gpm of lost pumping capacity would cost about $1,096 more per month. The Lummi Water District's rates would have to be raised an average of $2.26 for the current 485 residential customers if one 20 gpm well was lost. This increase represents about an 11 percent increase over the current average monthly Lummi Water District residential customer bill of $21.00. However, the simplified equation used to estimate the water replacement cost does not address the cost to the Lummi Nation of depleting a ground water resource in a region with a limited water supply. It is impossible to put a true value on a resource that is essential to life, is finite, and is irreplaceable.

A Phase II report documenting the status of the Lummi Wellhead Protection Program will be completed in March 1998. The report will document the implementation of the community involvement plan, the spill response planning effort, and the development of protection measures. The Phase II report will also identify the 1998-2000 action plan for the Lummi Wellhead Protection Program.

8. REFERENCES

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Appendix A: Wellhead Inventory

Lummi_No	Location	Owner	Reservation	Active	Well_Log	Year
85	37N/01E-02E01	JONES, VICTOR	Y	Y	N	999
86	37N/01E-02E02	JONES, VICTOR	Y	N	P	1964
87	37N/01E-02E03	WHATCOM COUNTY, LUMMI MARINE PARK	Y	N	P	1971
123	37N/01E-02E04	KINLEY, MARCELLINE	Y	Y	Y	1979
124	37N/01E-02E05	HILLAIRE, PENNY	Y	N	Y	1982
91	37N/01E-02H01	NAVARETTE, PETE	Y	N	P	1964
134	37N/01E-02H02	SMITH,JIM	Y	Y	Y	1985
164	37N/01E-02H03D1	BEWLEY, KEN	Y	N	N	999
172	37N/01E-02K01	BEZONA	Y	Y	N	999
173	37N/01E-02K02	BEZONA, BOB D.	Y	Y	N	999
174	37N/01E-02K03	YORKSTON	Y	Y	Y	1947
175	37N/01E-02K05	FILBERT, FRED	Y	Y	N	999
93	37N/01E-02K06	NOLTE,F. W.	Y	Y	N	999
92	37N/01E-02K07	ADAMS,JAMES	Y	Y	N	999
176	37N/01E-02K08	WALKER, WAYNE	Y	Y	Y	1956
192	37N/01E-02K09	FRANCISCO, J. E.	Y	N	N	999
90	37N/01E-02M01	SOLOMON, NICK	Y	Y	N	999
88	37N/01E-02M02	HILLAIRE, PENNY	Y	Y	N	999
89	37N/01E-02M03	SOLOMON, RALPH	Y	Y	P	1973
131	37N/01E-02M04	ORERIO, DAVE	Y	Y	Y	1980
130	37N/01E-02P02	LUMMI SEWER PLANT	Y	Y	Y	1982
132	37N/01E-02P03	LANE,CARL	Y	Y	Y	1987
193	37N/01E-02Q01	BARBER, ZILPHA	Y	N	N	999
94	37N/01E-02Q02	BARBER, JAMES	Y	N	P	1946
177	37N/01E-02Q03	LELAND, TROY & SUSAN	Y	Y	N	999
95	37N/01E-02Q04	SOLOMON, VICTOR	Y	Y	N	999
150	37N/01E-02Q06	DRUMHELLER, DOROTHY	Y	Y	Y	1994
178	37N/01E-02Q08	HARRIMAN, LARRY	Y	Y	N	999
147	37N/01E-02Q09	BEZONA, ROBERT	Y	Y	Y	1994
179	37N/01E-02Q10	OTT, JANET	Y	Y	N	999
180	37N/01E-02Q11	TRECKER, MARTECK C.	Y	Y	N	999
181	37N/01E-02Q12	HOLCOMB, LEE	Y	Y	Y	1956
133	37N/01E-02Q13	WORMALD, MARTIN & LAURIE	Y	Y	Y	1987
84	37N/01E-03H01	TOBY, VERLE	Y	N	N	999
96	37N/01E-11B01	MORSE	Y	Y	P	1970
97	37N/01E-11C01D1	LUMMI WTR DST, SOLOMON & LEWIS	Y	N	P	1954
194	37N/01E-11C01S	LUMMI INDIAN BUSINESS COUNCIL	Y	N	N	999
190	37N/01E-11C02	LUMMI WTR DST, SOLOMON & LEWIS	Y	Y	N	999
98	37N/01E-11K01	WHATCOM COUNTY (HIGHWAY DEPT)	Y	N	Y	1959
99	37N/01E-12L01	WHATCOM COUNTY (PARK DEPT)	Y	N	P	1964
27	38N/01E-01B01	LUMMI INDIAN BUSINESS COUNCIL	Y	N	P	1946
28	38N/01E-01B02	LUMMI INDIAN BUSINESS COUNCIL	Y	N	N	999
195	38N/01E-01N01	JEFFERSON, DAVE	Y	N	N	999
196	38N/01E-01Q01	USGS	Y	N	N	999
19	38N/01E-03D01	HILLAIRE, BENJAMIN	Y	N	P	1964
20	38N/01E-03D02	HILLAIRE, BENJAMIN	Y	N	P	1971
26	38N/01E-03H01	KINLEY, MAY (ESTATE)	Y	N	P	1964
222	38N/01E-03J01	LEE BROTHERS	Y	U	N	999
23	38N/01E-03M01	ESTATE OF A. CAGEY	Y	N	P	1964
24	38N/01E-03M02	PAIGE,VICTORIA	Y	N	N	999
25	38N/01E-03Q01	JAMES,CALVIN	Y	N	P	1964
144	38N/01E-04B01	ADAMS,BEVERLY & RON	Y	Y	N	999
223	38N/01E-04B02	USGS TEST HOLE	Y	N	Y	1956
102	38N/01E-04B03	INDIAN HEALTH SERVICE	Y	N	Y	1976
103	38N/01E-04B04	INDIAN HEALTH SERVICE	Y	N	Y	1976
9	38N/01E-04D03	NEPTUNE BEACH WATER ASOC	Y	N	Y	1953
10	38N/01E-04D04D1	NEPTUNE BEACH WATER ASOC	Y	Y	P	1970
11	38N/01E-04D05	NEPTUNE BEACH WATER ASOC	Y	Y	N	999
12	38N/01E-04E01	SANDY POINT IMPROVEMENT COMPANY	Y	N	Y	1960
14	38N/01E-04E02	SANDY POINT IMPROVEMENT COMPANY	Y	Y	Y	1971
13	38N/01E-04E03	SANDY POINT IMPROVEMENT COMPANY	Y	Y	Y	1969
107	38N/01E-04E04	SANDY POINT IMPROVEMENT COMPANY	Y	Y	Y	1985

Lummi_No	Location	Owner	Reservation	Active	Well_Log	Year
142	38N/01E-04E05	LUMMI INDIAN BUSINESS COUNCIL	Y	N	Y	1991
145	38N/01E-04E06	LUMMI INDIAN BUSINESS COUNCIL -	Y	Y	Y	1993
110	38N/01E-04E07	FINKBONNER, ARNOLD, WELL I	Y	N	S	999
108	38N/01E-04E08	FINKBONNER, ARNOLD, WELL II	Y	N	N	999
21	38N/01E-04J01	JOSEPH, DAVID	Y	N	P	1964
22	38N/01E-04J02	JOSEPH, JAMES	Y	N	P	1964
224	38N/01E-04J03	USGS TEST HOLE	Y	N	Y	1956
18	38N/01E-04J04	SANDY POINT IMPROVEMENT COMPANY	Y	N	Y	1969
16	38N/01E-04M01	FINKBONNER, FRED	Y	N	P	1964
15	38N/01E-04M02	FINKBONNER, FRED	Y	N	P	1964
396	38N/01E-04M03	DAWSON, MARLENE	Y	N	Y	1996
397	38N/01E-05	MAYHEW, FRANCES				
6	38N/01E-05A01	HERBERT SHERMAN	Y	U	P	1947
7	38N/01E-05A02D1	BAKER,M. PETE	Y	Y	P	1953
8	38N/01E-05A03	BURNETT, JACK	Y	N	N	999
149	38N/01E-05A04	BURRELL, NORMAN	Y	Y	Y	1993
104	38N/01E-05A05	BURNETT, MICHEAL	Y	Y	Y	1985
226	38N/01E-05A06	HARKLEROAD	Y	U	N	999
106	38N/01E-05A07	PETERSON, MARGE	Y	U	Y	1974
140	38N/01E-05A08	UNICK,FRANCIS	Y	Y	S	1968
100	38N/01E-05A09	UNKNOWN	Y	N	P	999
227	38N/01E-05H01	DAWLEY, HARRY	Y	U	Y	1951
228	38N/01E-05H02	O'DELL, ALLEN	Y	U	Y	1951
152	38N/01E-05H03	MCKAY, KENNETH	Y	Y	Y	1993
105	38N/01E-05H04	PUGLIA, JOHN	Y	U	Y	1976
139	38N/01E-05H05	JACKSON, ROBERT	Y	U	Y	1989
101	38N/01E-05J01	SKOLROOD, JOHN	Y	Y	Y	1982
229	38N/01E-05R01	FINKBONNER, JOHN	Y	U	Y	999
109	38N/01E-05R02	FINKBONNER, JOE	Y	Y	Y	1983
138	38N/01E-05R03	FINKBONNER, DARRIN	Y	Y	Y	1989
17	38N/01E-08A01	USGS	Y	N	Y	1956
39	38N/01E-11N01	LUMMI INDIAN BUSINESS COUNCIL	Y	N	N	999
40	38N/01E-11N02	LUMMI INDIAN BUSINESS COUNCIL	Y	N	P	1952
38	38N/01E-11R01	KINLEY, EVA	Y	N	P	1971
36	38N/01E-12H01	KINLEY, LARRY & ELLIE	Y	N	N	999
157	38N/01E-12J01	WILLIAMS, VIRGIL	Y	N	N	999
37	38N/01E-12K01	LUMMI INDIAN BUSINESS COUNCIL	Y	N	P	1952
197	38N/01E-12M01	JOHNS,HERBERT	Y	N	N	999
158	38N/01E-13C01	JONES,SADIE	Y	N	N	999
45	38N/01E-13J01D1	MARTIN, FRANK	Y	N	Y	1965
46	38N/01E-13J02	CHURCHOF JESUS CHRIST L.D.S.	Y	N	P	1969
47	38N/01E-13J03	EDWARDS, SANDRA	Y	N	P	1970
198	38N/01E-13J04	USGS	Y	N	Y	1956
199	38N/01E-13J05	MARTIN, FRANK	Y	N	N	999
44	38N/01E-13K01	TOM, ISADORE	Y	N	P	1971
200	38N/01E-14A01	USGS	Y	N	Y	1956
154	38N/01E-14H01D2	KOSEL,HORST	Y	N	Y	1994
42	38N/01E-14J01	HILLAIRE, NEDDIE	Y	N	P	1964
41	38N/01E-14J02	CHARLES, NORBERT	Y	N	P	1971
43	38N/01E-14Q01	TWINER, WILLIS	Y	Y	P	1970
111	38N/01E-14Q02	LUMMI TRIBE, HOPKINS	Y	N	Y	1991
155	38N/01E-14Q03	THRALL, TOM	Y	N	Y	1991
398	38N/01E-23A01	CURRAN, TROY	Y	N	Y	1995
399	38N/01E-23A02	CURRAN, TROY	Y	N	Y	1995
201	38N/01E-23B01	HARNDEN, M.F.	Y	N	Y	999
202	38N/01E-23B02	HARNDEN, M.F.	Y	N	Y	999
54	38N/01E-23B03	HARNDEN ISLAND VIEW	Y	Y	P	1958
113	38N/01E-23P01	WILLIAMS, VIRGIL	Y	Y	Y	1991
53	38N/01E-24G01D1	HUMPHREY, A. JR	Y	N	P	1964
203	38N/01E-24G02	HUMPHREYS, ART	Y	N	Y	1956
204	38N/01E-25C01	USGS	Y	N	Y	1956
63	38N/01E-25D01	LUMMI WTR DST, ROSS	Y	N	P	1971

Lummi_No	Location	Owner	Reservation	Active	Well_Log	Year
205	38N/01E-25J01	PETERS, AL	Y	N	N	999
66	38N/01E-25J02	PIERRE, ENEAS	Y	N	P	1964
65	38N/01E-25J03	USGS (LUMMI TW1)	Y	N	Y	1971
206	38N/01E-25J04	USGS	Y	N	Y	1956
64	38N/01E-25K01	BELL BAY INC	Y	Y	P	1961
171	38N/01E-25Q01	PLASTER, JIM	Y	Y	N	999
67	38N/01E-25Q02	PLASTER, JIM	Y	N	Y	1964
112	38N/01E-26C01	JEFFERSON, RALPH	Y	Y	Y	1989
55	38N/01E-26D01	OWSLEY& DURKIN	Y	N	Y	1965
57	38N/01E-26E01	BOYNTON SUNSET	Y	Y	Y	1962
56	38N/01E-26G01	LUMMI WTR DST, CULTEE	Y	N	P	1971
61	38N/01E-26J01	KINLEY, FLORENCE	Y	N	P	1967
182	38N/01E-26M01	ROBBINS, CAROLE	Y	Y	N	999
114	38N/01E-26M02	KENNEDY, KATHY	Y	Y	Y	1988
115	38N/01E-26N01	LUMMI WTR DST, BALCH	Y	Y	Y	1987
59	38N/01E-26Q01	LUMMI WTR DST, KINLEY WAY	Y	Y	Y	1971
207	38N/01E-26Q02	USGS	Y	N	Y	1956
166	38N/01E-26R01	PIERRE, JOHN	Y	N	N	999
208	38N/01E-26R02	PIERRE, ART	Y	N	N	999
62	38N/01E-26R03	PIERRE, JOHN	Y	N	P	1964
60	38N/01E-26R04	WIGGIN, CHARLES JR	Y	N	P	1964
119	38N/01E-27J01	ROBB, GEORGE M.	Y	Y	Y	1974
117	38N/01E-27J02	RICHARDSON, TOM	Y	Y	Y	1974
121	38N/01E-27J03	BRIAN,OLIVER	Y	Y	Y	1976
116	38N/01E-27J04	SMITH, MICHAEL	Y	Y	Y	1981
183	38N/01E-27J05	FADDEN & FISHER	Y	Y	Y	1988
184	38N/01E-27J06	HOVANDER, STEVE	Y	N	Y	1981
58	38N/01E-27R01	LUMMI WTR DST, HORIZON	Y	Y	Y	1968
122	38N/01E-27R02	NORTHGATE SHORT PLAT	Y	Y	Y	1981
151	38N/01E-27R03	PAUL DEGRAAF	Y	N	Y	1995
118	38N/01E-27R04	MURPHY, WAYNE & AUTRY, NICOLE	Y	Y	Y	1980
120	38N/01E-27R05	MOORE, GERALD	Y	Y	Y	1976
153	38N/01E-27R06	SCHNOBRICH, WILLIAM	Y	N	Y	1994
73	38N/01E-34A01	GEORGIA MANOR WATER	Y	N	Y	1959
186	38N/01E-34A02	GEORGIA MANOR WTR ASSC	Y	Y	Y	1992
146	38N/01E-34A03	LUMMI WTR DST, WEST SHORE	Y	Y	Y	1994
74	38N/01E-34B01	CHARLES, KATHY	Y	Y	P	1971
191	38N/01E-34B01S	LUMMI INDIAN BUSINESS COUNCIL	Y	N	N	999
75	38N/01E-34G02	SALISBURY, LEONARD	Y	Y	P	1969
76	38N/01E-34G03	BALLEW, WAYNE	Y	N	P	1963
127	38N/01E-34G04	LUMMI WTR DST, BALLEW-REVEY	Y	N	Y	1973
187	38N/01E-34G05	SALHUS, ROBERT	Y	Y	N	999
188	38N/01E-34G06	CLARK,JACK	Y	Y	Y	1985
143	38N/01E-34H01	BERG	Y	Y	Y	1977
125	38N/01E-34H02	HENDRICKSON, JAY & JOAN	Y	Y	Y	1977
81	38N/01E-34J01	GOOSEBERRY POINT	Y	N	N	999
128	38N/01E-34J02	LUMMI WTR DST, MACKENZIE I	Y	Y	Y	1982
230	38N/01E-34J03	GOOSEBERRY POINT WATER ASSOC	Y	N	N	999
80	38N/01E-34K01D1	LUMMI WTR DST, FISHERMANS COVE	Y	N	P	1946
78	38N/01E-34K03	LUMMI WTR DST, FISHERMANS COVE	Y	N	P	1968
79	38N/01E-34K04	LUMMI WTR DST, FISHERMANS COVE	Y	N	N	999
77	38N/01E-34P01	WHATCOM COUNTY (HIGHWAY DEPT)	Y	N	Y	1959
83	38N/01E-34Q01	JONES BROTHERS	Y	N	P	1947
82	38N/01E-34R01	GOOSEBERRY POINT	Y	Y	Y	1968
209	38N/01E-34R01S	GOOSEBERRY PT WTR ASSC	Y	N	N	999
129	38N/01E-35E01	LUMMI WTR DST, MACKENZIE II	Y	Y	Y	1987
72	38N/01E-35R01	JOHNSON, V.	Y	N	P	1946
189	38N/01E-35R02	LANE,JIM	Y	Y	Y	1991
210	38N/01E-36B01	USGS	Y	N	Y	1956
167	38N/01E-36C01	SOLOMON, DORA	Y	N	Y	999
168	38N/01E-36E01	SOLOMON, FELIX	Y	N	Y	999
211	38N/01E-36E02	USGS	Y	N	Y	1956

Lummi_No	Location	Owner	Reservation	Active	Well_Log	Year
170	38N/01E-36M01	WASHINGTON, BUCK OR DEAN	Y	N	N	999
30	38N/02E-05B01	ROBERT E TAWES	N	N	P	1972
29	38N/02E-06B01	IMHOFF, FRANK	Y	N	N	999
135	38N/02E-06P01	HOOD,PERCY	Y	Y	Y	1948
35	38N/02E-07E01	JAMES,BILL	Y	N	P	1958
31	38N/02E-07J01	JOHNSON, V.V.	Y	N	Y	1972
33	38N/02E-07M01	LUMMI SCHOOL	Y	N	P	1933
156	38N/02E-07M01S	LECKMAN & SHOEMAKER	Y	N	N	999
34	38N/02E-07M02	LUMMI SCHOOL	Y	N	N	999
162	38N/02E-07M02S	JAMES,JEWELL	Y	N	N	999
212	38N/02E-07M03	USGS	Y	N	Y	1956
161	38N/02E-07M03S	REVEY,BILL	Y	N	N	999
32	38N/02E-07Q01	MCKAY,J. & OTHERS	Y	N	Y	1972
213	38N/02E-18C01	JEFFERSON, FRANCIS	Y	N	N	999
214	38N/02E-18C02	JEFFERSON, FRANCIS	Y	N	Y	1956
163	38N/02E-18D01	JEFFERSON, FRANCIS & MIKE	Y	N	N	999
215	38N/02E-18F01	USGS	Y	N	Y	1956
216	38N/02E-18F02	USGS	Y	N	Y	1956
169	38N/02E-18L01S	WILLIAMS, MARTHA	Y	N	N	999
217	38N/02E-18P01	USGS	Y	N	Y	1956
136	38N/02E-18Q01	MAMOYA PONDS	Y	N	Y	1990
159	38N/02E-19B01S	CHARLES, GORDON	Y	N	N	999
165	38N/02E-19B02	MCCLAUSKEY, RUSSELL	Y	N	N	999
160	38N/02E-19G01S	CHARLES, ELLEN	Y	N	N	999
218	38N/02E-19G02	YUN, CHUNG	Y	N	N	999
219	38N/02E-19G03	USGS	Y	N	Y	1956
50	38N/02E-19L01	LARSEN, CHRIS	Y	N	N	999
51	38N/02E-19L02	CRUIKSHANK, N.P.	Y	N	P	1946
48	38N/02E-19L03	COSTELLO, ROBERT	Y	Y	Y	1956
49	38N/02E-19L04	COSTELLO, ROBERT	Y	N	P	1956
52	38N/02E-19P01	HUBBARD, VIC & BRAINARD, DIANE	Y	Y	N	999
221	38N/02E-19P02	USGS	Y	N	Y	1956
69	38N/02E-30D01	GREEN, RICHARD	Y	Y	P	1971
70	38N/02E-30D02	GREEN, EDMUND	Y	N	P	1964
68	38N/02E-30D03	CAGEY, MARY HELEN	Y	Y	P	1971
71	38N/02E-30E01	VICTOR, JOHN & PETE	Y	N	Y	1964
365	39N/01E-13D01	ALDER GROVE WATER ASSOCIATION	N	U	Y	1971
366	39N/01E-13D02	ALDER GROVE WATER ASSOCIATION	N	U	Y	1949
367	39N/01E-13H01WS	UNKNOWN	N	U	N	999
368	39N/01E-13Q01	THORTON WATER ASSOCIATION	N	U	Y	1951
369	39N/01E-14C01	UNKNOWN	N	U	N	999
370	39N/01E-14N01	UNKNOWN	N	U	N	999
371	39N/01E-14P01	NORTH STAR WATER ASSOCIATION	N	U	Y	1966
372	39N/01E-14P02	NORTH STAR WATER ASSOCIATION	N	U	Y	1950
373	39N/01E-14Q01	UNKNOWN	N	U	N	999
374	39N/01E-14Q02	WENDAL, JOE	N	U	Y	999
375	39N/01E-15B01	UNKNOWN	N	U	P	999
376	39N/01E-15B02	LAKE TERRELL WATER ASSOCIATION	N	U	Y	1970
377	39N/01E-15L01	UNKNOWN	N	U	N	999
378	39N/01E-16C01	UNKNOWN	N	U	N	999
379	39N/01E-17A01	UNKNOWN	N	U	N	999
380	39N/01E-17K01	UNKNOWN	N	U	N	999
381	39N/01E-17M01	UNKNOWN	N	U	N	999
382	39N/01E-17Q01	UNKNOWN	N	U	N	999
383	39N/01E-18E01	G.N. RAILROAD	N	U	Y	1944
384	39N/01E-18Q01	UNKNOWN	N	U	N	999
385	39N/01E-19D01	UNKNOWN	N	U	N	999
386	39N/01E-19H01	UNKNOWN	N	U	N	999
387	39N/01E-20H01	UNKNOWN	N	U	N	999
388	39N/01E-20M01	UNKNOWN	N	U	N	999
231	39N/01E-21G01D1	STATE GAME DEPT.	N	U	Y	1967
232	39N/01E-21N01	WAYLETT, JESS	N	U	N	999

Lummi_No	Location	Owner	Reservation	Active	Well_Log	Year
233	39N/01E-21R01	HARVEY HANSON	N	U	N	999
234	39N/01E-22G01	S R ROBERSON	N	U	N	999
235	39N/01E-22J01	UNICK, VICK	N	U	Y	1994
236	39N/01E-23Q01	LARSON, EUGENE	N	U	Y	1973
389	39N/01E-24B01	UNKNOWN	N	U	N	999
390	39N/01E-24C01	UNKNOWN	N	U	N	999
391	39N/01E-24D01	UNKNOWN	N	U	N	999
392	39N/01E-24H01	UNKNOWN	N	U	P	999
393	39N/01E-24J01	UNKNOWN	N	U	N	999
394	39N/01E-24P01	UNKNOWN	N	U	N	999
395	39N/01E-24R01	MOSTROM, A.	N	U	Y	999
237	39N/01E-25F01	HENRY DERR	N	U	N	999
238	39N/01E-25L01	O M SHEPPARD	N	U	N	999
239	39N/01E-26B01	MORELANDER, GEORGE	N	U	Y	1946
240	39N/01E-26C01	GILBERTSON, JIM	N	U	Y	1991
241	39N/01E-26D01	AMUNDSON, SAM	N	U	N	999
242	39N/01E-26E01	MACGUIRE, JOHN	N	U	Y	1940
243	39N/01E-26F01	ROBERTS, BILL	N	U	Y	1992
244	39N/01E-26F02	HAMILTON, LEON & JANINE	N	U	Y	1991
245	39N/01E-26G01	BARNES, GEORGE	N	U	Y	1993
246	39N/01E-26H01	KELLN, GOTFRIED	N	U	N	999
247	39N/01E-26H02	KOLSTAD, JULIA	N	U	Y	1980
248	39N/01E-26H03	KELLN, GOTFRIED	N	U	N	999
249	39N/01E-26J02	WIDMAN, LLOYD	N	U	Y	1992
250	39N/01E-26J03D1	MATHIS, GENE	N	U	Y	1981
251	39N/01E-26K01	EASTON, JAMES	N	U	Y	1981
252	39N/01E-26K02	CHORNLSESKY, BILL	N	U	Y	1981
253	39N/01E-26K03	WIDMAN, LLOYD	N	U	Y	1977
254	39N/01E-26M02	HALIGAN, PAUL	N	U	Y	1991
255	39N/01E-26M03	SOFIE, MIKE	N	U	N	999
256	39N/01E-26P01	KIMBLY, JAMES	N	U	Y	1988
257	39N/01E-26Q01	BUBB, DICK	N	U	Y	1981
258	39N/01E-26Q02	WIDMAN, LLOYD	N	U	Y	1988
259	39N/01E-26R01	BERARD, WILLIAM	N	U	Y	1972
260	39N/01E-26R03	SHANNON, PATRICK & FLORA	N	U	Y	1993
261	39N/01E-27B01	ANDERSON, A	N	U	N	999
262	39N/01E-27H01	BENSON, DEAN	N	U	N	999
263	39N/01E-27J01	WARREN, JIM	N	U	Y	1993
264	39N/01E-27L01	VAN SCHINDE L,J.	N	U	Y	1945
265	39N/01E-27P01	RIGHT, J. C.	N	U	Y	1988
266	39N/01E-27R01	BRESLAND, FRANK	N	U	Y	1989
267	39N/01E-28D01	BAILEY, JAY	N	U	Y	999
268	39N/01E-28E01	ANDERSON, CARL W.	N	U	Y	1940
269	39N/01E-28E02	INTALCO	N	U	Y	1965
270	39N/01E-28M01	UNICK, LOUIS	N	U	Y	1947
271	39N/01E-28M02	INTALCO	N	U	N	999
272	39N/01E-29B01	KYNELL, FRED	N	U	Y	1947
273	39N/01E-29B02	KYNELL, FRED	N	U	Y	1946
274	39N/01E-29J01	DAY, JAMES	N	U	Y	999
275	39N/01E-32H01	GODDARD, WILLIAM F.	N	U	N	999
276	39N/01E-32H02	TOSCO REFINERY	N	U	Y	1981
277	39N/01E-32J01	TOSCO REFINERY	N	U	Y	1981
278	39N/01E-33A01	THIESSEN, H.W.	N	U	Y	1941
279	39N/01E-33B01	TOSCO REFINERY	N	U	Y	1981
280	39N/01E-33D01	UNICK, ELLSWORTH	N	U	N	999
281	39N/01E-33E01	TOSCO REFINERY	N	U	Y	1981
282	39N/01E-33H01	GENERAL PETROLEUM	N	U	N	999
283	39N/01E-33N01	TOSCO REFINERY	N	U	Y	1982
284	39N/01E-33P01	WARNER, D. E.	N	U	N	999
285	39N/01E-34A01	NORDTVEDT, THOMAS	N	U	Y	1946
286	39N/01E-34A03	DOMPE, DEANNA	N	U	Y	1992
287	39N/01E-34B01	FORHAN, CRAIG	N	U	Y	1991

Lummi_No	Location	Owner	Reservation	Active	Well_Log	Year
288	39N/01E-34C01	TROUT, ROBERT	N	U	Y	1991
290	39N/01E-34D03	HOFFMAN, E.	N	U	Y	1991
291	39N/01E-34E01	NEVINS, J.A.	N	U	Y	1935
292	39N/01E-34F01	RENNER, ROGER	N	U	Y	1991
293	39N/01E-34J01	ONEAL, MICHEAL	N	U	Y	1981
294	39N/01E-34J02	DEMEYER, ROBERT C.	N	U	Y	1987
295	39N/01E-34J03	PARFOMCHUK, STEVE	N	U	N	999
289	39N/01E-34K01	BENNETT, JULIE	N	U	Y	1993
296	39N/01E-34M01	WEED, ERNIE III	N	U	Y	1992
297	39N/01E-34N01	BLUNT, LYNN	N	U	N	999
298	39N/01E-34N02	LYNN BLUNT	N	U	N	999
141	39N/01E-34N03	BARLEANS	N	U	Y	1988
299	39N/01E-34P01	UNICK, LOUIS	N	U	N	999
300	39N/01E-34P03	PARK, DAN	N	U	Y	1980
301	39N/01E-34P05	EDINGER SWINE FARM	N	U	Y	1980
5	39N/01E-34Q01	LOUIS UNICK	N	U	N	999
302	39N/01E-34Q02	JONES, GERALD	N	U	Y	1981
4	39N/01E-34R01	JORDAN AND LARSON	N	U	N	999
303	39N/01E-35A03	ENFIELD, PAUL	N	U	Y	1980
304	39N/01E-35C01	STILLWELL, IDELLA	N	U	N	999
305	39N/01E-35D02	WILSON, RUSSEL	N	U	Y	1991
306	39N/01E-35D03	O'NEAL, JON	N	U	Y	1991
307	39N/01E-35E01	AMUNDSON, RAY	N	U	Y	1973
308	39N/01E-35E02	LEVIEN, JOHN	N	U	Y	1987
309	39N/01E-35M01	FERGNSON, JIM	N	U	N	999
3	39N/01E-35N01	CLEMO, BECK N.	N	U	P	1962
310	39N/01E-35N02	BUSCH, JOHN	N	U	Y	1992
311	39N/01E-36F01WS	UNKNOWN	N	U	N	999
312	39N/02E-17E01	UNKNOWN	N	U	N	999
313	39N/02E-17K01	UNKNOWN	N	U	N	999
314	39N/02E-17M01WS	UNKNOWN	N	U	N	999
315	39N/02E-17N01	UNKNOWN	N	U	N	999
316	39N/02E-17Q01	UNKNOWN	N	U	N	999
317	39N/02E-17Q02	UNKNOWN	N	U	N	999
318	39N/02E-17R01	UNKNOWN	N	U	N	999
319	39N/02E-18B01	UNKNOWN	N	U	N	999
320	39N/02E-18B02	UNKNOWN	N	U	N	999
321	39N/02E-18C01	BIDLINGTON, YESTER	N	U	Y	1974
322	39N/02E-18D01	UNKNOWN	N	U	N	999
323	39N/02E-18F01	UNKNOWN	N	U	N	999
324	39N/02E-18F02	UNKNOWN	N	U	N	999
325	39N/02E-18G01	UNKNOWN	N	U	N	999
326	39N/02E-18H01	UNKNOWN	N	U	N	999
327	39N/02E-18K01	UNKNOWN	N	U	N	999
328	39N/02E-18K02	UNKNOWN	N	U	N	999
329	39N/02E-18N01	UNKNOWN	N	U	N	999
330	39N/02E-19A01	FRY, W.	N	U	Y	1946
331	39N/02E-19B01	IVERSON, OLE	N	U	Y	1947
332	39N/02E-19C01	UNKNOWN	N	U	N	999
333	39N/02E-19E01	CENTRAL CITY WATER ASSOCIATION	N	U	Y	1970
334	39N/02E-19F01	ESTEP, JOHN W.	N	U	Y	1969
335	39N/02E-19G02	UNKNOWN	N	U	N	999
336	39N/02E-19H01	TOWN OF FERNDALE	N	U	Y	1936
337	39N/02E-19H02	UNKNOWN	N	U	N	999
338	39N/02E-19H03	UNKNOWN	N	U	N	999
339	39N/02E-19H04	UNKNOWN	N	U	N	999
340	39N/02E-19H05	UNKNOWN	N	U	N	999
341	39N/02E-19H06	UNKNOWN	N	U	N	999
342	39N/02E-19K01WS	UNKNOWN	N	U	N	999
343	39N/02E-19L01	UNKNOWN	N	U	N	999
344	39N/02E-19M01	UNKNOWN	N	U	N	999
345	39N/02E-19N01	UNKNOWN	N	U	N	999

Lummi_No	Location	Owner	Reservation	Active	Well_Log	Year
346	39N/02E-19P01	BOHN, H.E.	N	U	Y	1945
347	39N/02E-19Q02	TOWN OF FERNDALE	N	U	Y	1955
348	39N/02E-19Q03	UNKNOWN	N	U	N	999
349	39N/02E-20C01	HEGGEN, H	N	U	Y	1942
350	39N/02E-20F01	UNKNOWN	N	U	N	999
351	39N/02E-20F02	UNKNOWN	N	U	N	999
352	39N/02E-20G01	UNKNOWN	N	U	N	999
1	39N/02E-29M01	WHATCOM CO HWY	N	U	P	1972
353	39N/02E-30C01	SCHOESSLER, JACOB	N	U	Y	1944
354	39N/02E-30C02	UNKNOWN	N	U	N	999
355	39N/02E-30C03	HUGHES, HOMER H.	N	U	Y	1970
356	39N/02E-30C04	HONG, GEORGE R.	N	U	Y	1969
357	39N/02E-30C05WS	CITY OF FERNDALE	N	U	Y	1994
358	39N/02E-30F01	NASSON, HAROLD	N	U	Y	1974
359	39N/02E-30F02WS	UNKNOWN	N	U	N	999
360	39N/02E-30K01	UNKNOWN	N	U	N	999
361	39N/02E-30L01	HARLAND, C.H.	N	U	Y	1942
362	39N/02E-30L03	UNKNOWN	N	U	N	999
363	39N/02E-31C02	UNKNOWN	N	U	N	999
364	39N/02E-31H01	PETERSON, FRANK M.	N	U	Y	1947
2	39N/02E-31H02	WHATCOM CO HWY	N	U	P	1972
126	NONE	NONE	Y	N	N	999
137	NONE	NONE	N	U	N	999
148	NONE	NONE	N	U	N	999
185	NONE	NONE	N	U	N	999
220	NONE	NONE	N	U	N	999
225	NONE	NONE	N	U	N	999

Appendix B: *Squol Quol* Draft Article

What is Wellhead Protection?
by the Lummi Water Resources Division

Wellhead protection sounds like an anti-drug or alcohol program, and in a way it is similar. It helps protects our ground water from pollution just as anti-drug and alcohol programs help protect our minds, bodies, families, and community from pollution and poison.

In many cases, toxic substances spilled on the ground surface eventually make their way into the ground water system. The result can be a water supply that is no longer useable. Similarly, over pumping of wells near marine waters can cause the salt water to move into the fresh ground water system and make it unusable. A program that a government develops to help protect ground water from pollution is called a "Wellhead Protection Program". The Lummi Nation is developing a wellhead protection program because contamination of ground water resources on the Reservation has a direct, serious, and substantial effect on the political integrity, economic security, and the health and welfare of the Lummi Nation, its members, and all persons present on the Reservation.

In 1996, ground water pumped from the six production wells operated by the Lummi Water District supplied almost all (over 90 percent) of the water delivered to the District's customers. The rest of the water supplied by the District was imported from the City of Bellingham at higher costs. Many other Reservation residents rely exclusively on ground water wells for their water supply. Because of our reliance on ground water and the cost of replacing this water supply source, it is critical that we protect this important resource.

To prevent the pollution of our primary water supply source, the Lummi Water Resources Division is developing a wellhead protection program for the Reservation. The wellhead protection program is being developed for several important reasons including:
1. Our ground water system is vulnerable to pollution,
2. Water supply wells are difficult to replace, and
3. Contamination is expensive to treat.

The Lummi Nation's wellhead protection program will be similar to the programs developed by other communities throughout the United States. Major components of the wellhead protection program will include community involvement, a susceptibility assessment, contingency planning, spill response planning, and the development of protection measures.

<u>Community involvement</u> is a critical element in a wellhead protection program and will be solicited in the development and implementation of the program. Articles similar to this one will appear in the *Squol Quol* and presentations about the program will be provided to the various LIBC commissions and to other interested groups.

A <u>susceptibility assessment</u> evaluates the vulnerability of a ground water well to contamination. The susceptibility assessment, which has been completed, consisted of an inventory of water supply wells, identification of wellhead protection areas, and an inventory of potential sources of pollution (both historic and current potential sources) in each wellhead protection area.

Contingency plans are developed to prepare for an emergency that would cause our water supply system to be unusable. The plan, which has also been completed, analyzed water supply replacement options and associated costs.

Spill response plans will be developed in the coming months in coordination with local emergency responders (e.g., law enforcement, fire department, Cherry Point industries).

Wellhead protection measures will be developed as part of the community involvement component of the program. These measures may include land use ordinances, permit review requirements, standards for new industry and businesses, purchase of property, water conservation, household hazardous waste collection, public education initiatives, and decommissioning of unused or abandoned wells.

In summary, the Lummi Nation Wellhead Protection Program is intended to prevent pollution before it happens. The Lummi Water Resources Division is developing the program because the primary water supply on the Reservation is vulnerable, our wells would be difficult to replace, and contamination is expensive to treat. Water is necessary for life, as we all know, and protection of our ground water for our children and grandchildren is a responsibility we take seriously. If you have any questions about the program, please contact Leroy Deardorff at 384-2272.

Appendix C: Wellhead Protection Program Slide Presentation

Wellhead Protection Program Overview

Lummi Indian Nation's Wellhead Protection Program

Lummi Indian Business Council
Lummi Water Resources Department

Presentation Objectives

By the end of the presentation, participants will be able to:

- State the purpose of the wellhead protection program,
- List four reasons why the program is needed, and
- Discuss the five major components of the program

Presentation Outline

- Introduce Wellhead Protection
- Describe the Major Components of a Wellhead Protection Program
- Summary
- Questions and Answers

What is a Wellhead?

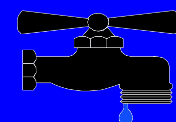
- The physical structure, facility, or device at the land surface from or through which ground water flows or is pumped from water-bearing formations (i.e., aquifers).

What is a Wellhead Protection Program?

- It is a program designed to prevent contamination of ground water used for drinking water supplies

Why is a Wellhead Protection Program Needed?

- Over 90 percent of the water supplied by the Lummi Water District comes from the Lummi Nation's six production wells.
- Ground water systems are vulnerable to contamination.
- Wells are difficult to replace.
- Contamination is expensive to treat.



Wellhead Protection Program Overview

What Are the Major Components of a Wellhead Protection Program?

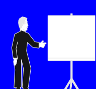
- Community Involvement
- Hazard Assessment
- Contingency Plans
- Spill Response Plans
- Develop Protective Measures

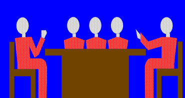
Community Involvement: Why is it Necessary?

- Ground water does not respect private property or political boundaries.
- Community participation in development and implementation of the resulting management plan is critical to program success.

Community Involvement: Methods

- Public Education
  - Presentations to Tribal Councils
  - Presentations to Tribal Commissions
  - Presentations to Interested Groups
  - Articles in Squol Quol
- Interjurisdictional Coordination and Cooperation





What Are the Major Components of a Wellhead Protection Program?

- Community Involvement
- Hazard Assessment
- Contingency Plans
- Spill Response Plans
- Develop Protective Measures

What is a Hazard Assessment?

- An evaluation of how vulnerable a well is to contamination.

What Factors Affect the Vulnerability of a Well?

- Physical Characteristics that Affect the Entry of Contaminants into a Well.
- The Risk that a Well is Exposed to Contaminants.

Wellhead Protection Program Overview

What are the Key Elements of a Hazard Assessment?

- Characterization of the Well and the Hydrogeological Setting
- Delineation of Wellhead Protection Areas
- Inventory Potential Contaminant Sources

What is a Wellhead Protection Area?

- The surface area overlying the short-term zone that contributes water to a well or spring.
- The area managed by a community to protect ground water sources of drinking water.

Delineation of Wellhead Protection Areas - Technical Criteria

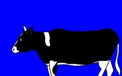
- Distance
- Drawdown
- Time of Travel
- Flow Boundaries
- Assimilative Capacity

How Are Wellhead Protection Area Boundaries Determined/Mapped?

- Calculated Fixed Radius Method
- Analytical Modeling
- Hydrogeological Mapping
- Numerical Modeling

Inventory of Potential Contaminant Sources

- Historical Sources
- Existing Sources
  - Business
  - Agriculture
  - Homeowners
- Future/Proposed Land Uses



How is the Inventory Conducted?

- Review Existing Information/Data
- Perform Surveys
- Field Studies
- Interview

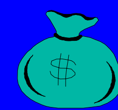
Wellhead Protection Program Overview

What Are the Major Components of a Wellhead Protection Program?

- Community Involvement
- Hazard Assessment
- Contingency Plans
- Spill Response Plans
- Develop Protective Measures

What is a Contingency Plan?

- An Analysis of Options and Costs to Replace the Water Source
- Documents the Value of the Existing Source



Why Develop a Contingency Plan?

- To Be Prepared In Case of an Emergency

What Are Other Uses of a Contingency Plan?

- Educational Tool for Decision-Makers
  - Cost of Replacement May Justify Protection Efforts.
  - Informed Officials May be More Willing to Utilize Land Use Regulations in Wellhead Protection Areas.

What Are the Major Components of a Wellhead Protection Program?

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Spill Response Plans

- Coordination with Local Emergency Responders (e.g., Police, Fire Department)
- May Need to Change Procedures in Sensitive Wellhead Protection Areas

Wellhead Protection Program Overview

What Are the Major Components of a Wellhead Protection Program?

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What Are Possible Wellhead Protective Measures?

- Zoning Ordinances
- Subdivision Ordinances
- Site Plan Review
- Design/Operating Standards
- Source Prohibitions

What Are Possible Wellhead Protection Measures (continued)?

- Purchase Property/Development Rights
- Water Conservation/Withdrawal Rates
- Household Hazardous Waste Collection
- Ground Water Monitoring
- Public Education

In Summary:

- The Wellhead Protection Program is a Proactive (Rather than a Reactive) Approach to Pollution Prevention and Risk Reduction.

Why is Wellhead Protection Important?

- Because Most of the Water Used on the Reservation Comes from Wells
- Ground Water Systems Are Vulnerable to Contamination
- Wells are Difficult to Replace
- Contamination is Expensive to Treat

For More Information, Please Contact:

Leroy Deardorff, Environmental Director
or
Jeremy Freimund, Water Resources Planner
Lummi Water Resources Department
Lummi Natural Resources Department
2616 Kwina Road
Bellingham, WA 98226-9298
(360) 384-2272 or (360) 384-2396